SCHOOL SCIENCE AND MATHEMATICS

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FRONTIERS

ALLEN F. MEYER

President, The Central Association of Science and Mathematics Teachers

The fiftieth anniversary convention program has been formulated. This represents the cooperation of group and section chairmen with the general officers of the Association. Without attempting to exploit the names of the speakers who have been asked to help us as we recognize the past and examine "Frontiers in Teaching of Science and Mathematics," we are proud to call to the attention of the reader and his friends each and every one of the speakers.

The General Superintendent of Chicago Schools, Dr. Herold C. Hunt, who will speak at the opening general session, very appropriately, has the theme of the convention for the title of his talk.

At the second general session, Professor Harlow Shapley, Director of the Harvard Observatories, has chosen "Galaxies for the Classroom," as the title for his talk. Frontiers in the material for teaching will form the basis for Professor Shapley's talk.

"An Industrialist Looks at Education" is the title of the banquet speech to be delivered by Mr. B. D. Kunkle, Senior Vice President of General Motors Corporation. In the realm of evaluation, here will be something of an opportunity for teachers to look at themselves and their work through the eyes of another. Perhaps industry may be thought of as one of the important consumers of the stock in trade which school teachers have to offer, both in the broader scope of education and in the particular of subject matter.

Professor Hermann Joseph Muller, famous geneticist of Indiana University, has recently been called upon to examine "The Need of Defending the Social Foundations of Science." He has kindly consented to present some of his findings to the Association at the final general session.

In addition to the guest speakers on the programs of the general sessions, members of the Association will appear. Franklin Frey is scheduled to present emeritus memberships. Marie S. Wilcox and Arthur O. Baker will direct attention to recognize the past, present, and future activity of the Association and its members. Kenneth Vordenberg, John R. Mayor, and Helen Monroe will present informational reports relating to the Policy Projects of the Association, which have been under way for the past few years.

The Section Meeting and Group Meeting programs are rich with talent. The announced topics scheduled for consideration indicate the gifts of the past and the hopes of the future. Inspirational and practical suggestions for teachers are promised. The chairmen are enthusiastic over the discussions and demonstrations they have arranged, and so have been others who have seen publicity releases.

Joint meetings with the National Council of Geography Teachers stimulate considerable interest in the Geography Section and Conservation Group Meetings. A joint mixer furnishes special opportunity to get acquainted with speakers and fellow members at the convention. The reports of Winnafred Shepard, Chairman of the Mixer, are worthy of special mention as one indication of the high level of hospitality being provided by the Local Arrangements Committees. The Trip Committee and other committees are determined not to be outdone. Results are already apparent. The business manager reports that, currently, paid memberships are ahead of this period for previous years.

The pleasure and inspiration of seeing old friends and making new friends at the golden anniversary convention, November 23, 24, and 25, at the Edgewater Beach Hotel in Chicago, will be worth remembering for a very long time. See a résumé of the "Golden Anniversary" program on a later page.

ON THE CREST

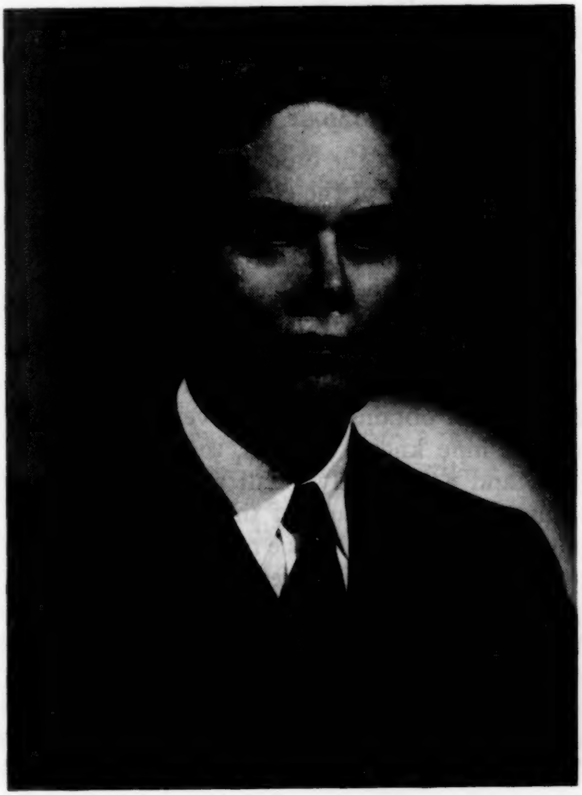
1950 is a most significant milestone for CASMT, it is the great anniversary year. The outstanding feature, however, is that in commemoration of the celebration the members saw fit to place a useful tool and a great document at the disposal of science and mathematics teachers:

FIFTY YEARS OF TEACHING SCIENCE AND MATHEMATICS

The book is a splendid tribute, a valuable source of quick information, a good-looking book. We applaud the authors, and the editorial

committee: Mrs. Jerome Isenbarger, Chicago, chairman, Miss Mary Potter, Racine Wisconsin, Mr. Walter G. Gingery, Indianapolis for the successful completion of an outstanding piece of work.

CONGRATULATIONS!



WALTER H. CARNAHAN
Editor-in-chief

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THE PROMOTIONAL COMMITTEE

Has your school library ordered a copy of FIFTY YEARS OF TEACHING SCIENCE AND MATHEMATICS? The small sum of $3.00 could not serve more effectively.

ASTRONOMY FOR THE ELEMENTARY SCIENCE CLASS[1]

WALTER G. GINGERY
George Washington High School, Indianapolis, Indiana

ASTRONOMIC SPACE, LIKE ATOMIC SPACE, IS ALMOST WHOLLY VACANT

The hydrogen atom is of the order of one 250 millionth of an inch in diameter. The diameter of the electron is something like one one-hundred thousandth of that and the diameter of the proton is much smaller than the electron. Since the hydrogen atom contains one proton and one electron, the occupied part of the space assigned to the hydrogen atom is about as 2 is to $(100,000)^3$ or as 1 is to $5 \cdot 10^{14}$. The figures for other atoms do not differ widely from that of hydrogen. Almost all of the space assigned to an atom is empty space.

A similar situation obtains in the heavens. The solar system consists of the sun, nine known planets, some twenty odd satellites, the planetoids and a relatively small amount of meteoric matter. To get a comprehensible picture of the solar system and the space assigned to it let us use a scale of one million miles equals a foot. The material of the solar system is spread almost in a plane. The orbit of Mercury, which is the smallest planetary orbit is inclined to the plane of the Ecliptic only about 7° and this is the greatest inclination of any planet's orbit.

On our scale the sun would be a globe about $10\frac{1}{3}$ inches in diameter. If we place the globe in the middle of a level field the following table will give the approximate sizes of the planets and the mean radii of their sensibly circular orbits.

	Size, Diameter	*Sample object, Diameter*	*Approximate radius of orbit*
Sun	864,392 mi.	10 in. globe	
Mercury	3,009	0.036 in. small clover seed	36 ft.
Venus	7,701	0.082 in. small birdshot	67 ft.
Earth	7,918	0.095 in. birdshot	93 ft.
Mars	4,339	0.052 in. clover seed	142 ft.
Jupiter	88,392	1.06 in. red plum	483 ft. (short city block)
Saturn	74,163	0.89 in. large cherry	866 ft. ($1\frac{1}{2}$ city blocks)
Uranus	30,193	0.36 in. medium cherry	1782 ft. $\frac{1}{3}$ mile
Neptune	34,823	0.42 in. another cherry	$\frac{1}{2}$ mile
Pluto	circ. 5000	0.06 in. clover seed	$\frac{7}{10}$ mile

[1] Part of a Science Symposium for grade and high school teachers at Butler University, July 25, 1950. Submitted as a request article. J. E. P.

On this scale the nearest known star, α-Centauri, which is distant about three light years would be at a distance of 3000 miles.

Obviously it would not be possible, with the unaided eye, to see all the above obejcts from any one point in our mile-and-a-half wide field. Neither is it possible with the full size model. We can see from earth, all the planets out to and including Saturn but, without optical aid we cannot see Uranus, Neptune or Pluto. If we were on one of these three planets we would not be able to see any of the four inner planets.

All the material in the solar system would occupy a sphere less than a million miles in diameter. If we assign to the solar system the space in a sphere whose radius is half the distance to α-Centauri we would seem to have a reasonable basis for comparison of space occupied to vacant space. This time the figure is 1 to $(15,000,000)^3$ or 1 ro 3.10^{21}.

It is possibly a reasonably safe assumption that the stars, on the average, are as far apart as the distance from the sun to α-Centauri. That is, they average 3 light years apart. Astronomical distances are so great that a special unit is employed to express them. The light year is the distance traversed in one year by a ray of light. Its velocity is 186,330 miles per second. (To keep pace with a ray of light a cyclist would require bicycle wheels as large as the earth's equator revolving seven times per second).

Do Other Stars Have Planets?

The question "Do other stars have planets similar to those in the family of the sun?" is often asked. The answer is not known. If an observer with normal human sight and the equal of our most powerful telescope were situated at the distance of the nearest star he would be unable to detect the presence of any of our planets. Similarly if there are planets like our planets about any of our neighboring stars no means at our command would detect them. The law of averages would seem to favor their existence. A good case might be made for the probability of conditions favoring life as we know it occurring in several other systems.

Interesting Siderial Objects

If we look with the unaided eye at the stars the major differences we can discover among them are the items of color and brightness. Some stars have a redidsh tinge like a hot iron that is below white heat. Others are slightly on the blue side. Early students of the stars classified the naked eye stars according to their brightness into six magnitudes. The first magnitude stars were the brightest. They also observed some stars whose brightness varies.

With the aid of telescope and spectroscope much more has been learned about many stars. It must be observed, however, that even with the best telescopic aid very little direct information can be learned about a single star. One of the most commonly observed deviations is the double or multiple star. Some double stars may be separated into components directly by our good telescopes. In other cases their existence must be inferred from observations of Fraunhofer lines with the spectroscope.

Of the 5400 stars in the first 9 magnitudes one in eighteen is multiple. In case both components of a double star are bright enough for their spectra to be observed we may infer their individual masses, their distance apart, their period of revolution and much about the chemical constitution of their gaseous enveolpes. And all this is learned about a pair of stars so remote that our most powerful telescopes show them as only a single point of light.

One other double star phenomenon should be described. Some times the orbits of a pair of stars are so placed that they eclipse each other as viewed from the earth. When this occurs there is a definite and marked diminishing of brightness occurring at regular intervals. About 100 such doubles with periods of 5 days or less are known.

Polaris, the pole star, has a faint telescopic companion revolving about it, or rather about their common center of gravity, in a period of about 12 years. In addition the brighter component is a spectroscopic double with a period of about 4 days.

A person with good sight can detect a faint star very close to Mizar, the star at the bend in the handle of the great dipper. This faint star is called Alcor. Alcor is a spectroscopic double with both spectra observable. Mizar itself is a telescopic double made up of two pairs of spectroscopic doubles. Both spectra show in the brighter pair. Only one spectrum is observable in the other.

If there were a planet revolving about Mizar its seasons as well as day and night sequences would be complicated.

Spica, the brightest star in the constellation Virgo was the first of the spectroscopic doubles to be studied. It is a first magnitude star and both spectra can be seen. It has a period of about four days. The components are about eleven million miles apart. In terms of the mass of the sun the masses of the components are 9.6 and 5.8.

Algol is the best known double of the eclipsing type. It is the star β in the constellation Perseus. At the time of eclipse it loses 5/6 of its brightness. This variation has been known since remote antiquity. Some of the ancients seem to have regarded it as the eye of a demon that winked. Its period is 2 d. 20 hr. 48 m. 55 s. Its components are 3 million miles apart and are approximately 800,000 and 1,000,000

miles in diameter. They have about one fourth the density of the sun.

The Constellations

It is interesting to speculate about the readiness with which one of us moderns, who happened to be reared as Romulus and Remus were without benefit of human intelligence, would become aware of the orderly sequence of atsronomic events. Certainly one must early recognize the diurnal motion of the sun, The regular recurrence of the moon's phases would take longer. Annual variations such as change of seasons and the sun's variation in declination as well as its eastward motion among the constellations would be still less likely to suggest themselves to our consciousness. Worried about the reactions of malicious superhuman beings, primitive peoples must have had a difficult time of it.

Next to the daily motion of the sun and the phases of the moon probably the most obvious astronomic phenomena are the configurations of visible stars known as the constellations. If the race had a childhood the constellations seem to have occupied part of its thought from the nature of some of the legends that have been preserved. Almost universally the constellations were animated and often personified or deified. In one of these, Jupiter's infatuation for the nymph Callisto and his wife Juno's consequent jealousy brought about the transformation of Callisto into a bear. When Arcas, Callisto's hunter son, came upon her in the woods and was about to kill his mother Jupiter intervened and transformed him also into a smaller bear.

To avoid Juno's further wrath Jupiter seized each bear in turn by the tail and with his great strength swung them about his head and threw them into the heavens. The terrific strain abnormally elongated their tails. Still Juno conspired with Neptune to forbid them the privilege of a rest beneath the waters after each journey across the heavens. They may not even touch the ocean for a cooling drink They are circumpolar stars

Another story involves Cepheus, King of Ethiopia, his vain Queen, Cassiopea, their beautiful daughter Andromeda, the dragon Cetus and the hero Perseus. With these legends and a star chart the northern constellations can be rather easily identified and learned.

Orion the hunter is an easily observed constellation in the southeastern autumn sky. It will amply repay a little study. Beside three double stars and the great Orion Nebula it contains Betelgeuse the first of the giant stars to be measured by Dr. Michaelson with the interferometer. In 1920 the scientific world was amazed by his an-

nouncement that the diameter of this star is so great that if its center were placed at the sun the star would contain the orbits of Mercury, Venus and Earth and extend almost to the orbit of Mars. The volume of Betelgeuse is more than 15 million times that of the sun and it is 325 light years distant. Diagonally across the constellation from Betelgeuse is Rigel whose intrinsic brightness is 2000 times as great as that of the sun.

The Galaxy

The sun quite certainly belongs to a system of stars of which it may be but an average star. Because of distance the great majority of these stars are visible only in the most powerful telescopes. The remote ones seem concentrated in a belt about the heavens called the milky way. Various estimates of the number of stars in this system, known as the galaxy, range from two billion to twenty billion. They are believed to occupy a space shaped somewhat like a thin model watch extending in the plane of the milly way. The diameter of the Galaxy may be as much as 50,000 light years while its thickness is one fourth as great. The sun is probably not near the center of the galaxy but is estimated to be about thirty thousand light years from the center of the Milky Way.

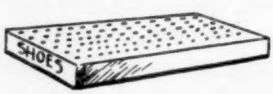
Astronomers in general believe that this is probably only one of many somewhat similar galaxies which possibly are related as members of a super-galaxy.

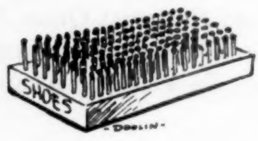
A CHAIN REACTION WITHOUT MOUSE TRAPS

James B. Davis
Lower Merion Senior High School, Ardmore, Pa.

An interest-arousing demonstration with a few simple materials is shown by the diagrams. Use the lid of a shoe box. Puncture holes in the lid about one-half inch apart. Fill in the holes with ordinary wooden matches. Light one corner match and it will set off others in turn, illustrating in a simple fashion, a chain reaction. The demonstration may be made more spectacular by using the trick matches that make a slight report after burning a few seconds. While this latter adds nothing to the science of the demonstration, it may act as a stimulator.

The diagrams were drawn by James Doolin, Lower Merion Senior High School, Ardmore, Pa.





APPRECIATION AND THE YOUNG MATHEMATICIAN

MARYBELLE GARRIGAN
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How can we give children in the primary grades an appreciation of arithmetic?

In his book, *Educational Psychology*,[1] H. C. Witherington states that appreciation, the least understood and the most important phase of education, is concerned with developing a favorable attitude toward particular values in any of the phases of human culture.

> "To enumerate the various fields of appreciation is to mention all the fields of human learning and not merely the fine arts."

He adds that while marked progress has been made in identifying and measuring values of gold and property of all kinds, less progress has been made in developing appreciation in the school subjects so that pupils will respond warmly and sympathetically to the sublime achievements of the ages.

This same point of view is expressed by the authors of *Modern Methods and Techniques of Teaching*.[2]

> "There is probably no other type of school activity that has been so misunderstood, misapplied, and subjected to so much formalism as activity in which appreciation is the chief and ultimate aim of teaching. The situation presents a challenge to the teacher of art, music, and literature and also to the teacher of science, history, and mathematics."

Appreciation in arithmetic involves more than a familiarity with the facts, information and techniques. It is when these function to attain a desired goal that the value and significance of arithmetic is appreciated. It is not something which comes at the wave of a wand, but rather it develops over a period of time and presupposes a wealth of experiences.

Granting these facts, it follows that there is need to lay a foundation as early as in the primary grades if appreciation of arithmetic is to be developed. What appreciation of arithmetic does the first grader have? Does not immaturity place forbidding limitations?

I directed an activity at the Kozminski School in Chicago in an attempt to find an answer to these questions. The pupils in one of the first grade rooms of that school were asked, as the school year closed in June, 1949, to list in written form the ways in which they used numbers in their daily lives. It was suggested that they place on the left hand side of the page the number symbol and write op-

[1] H. C. Witherington, *Educational Psychology*, Ginn & Co., New York, 1946, 299.

[2] Gerald Yoakam and Robert Simpson, *Modern Methods and Techniques of Teaching*, The Macmillan Co., New York, 1949, 123.

posite it the number situation in which it was used. The group of thirty, who were present on that date, had participated in a program which emphasized a functional approach to arithmetic and development of a rich experiential background for numbers.

A total of 109 different number situations were listed by the pupils without any direction from the teacher. The frequency range varied from 28 pupils mentioning a number situation to 1 pupil mentioning specific number situations.

Sarah wrote as follows:

"107 my room number
17 the date
12½ the number in my shoes
5207 Inglside my house number
Midway 3-5434 my number to call
6½ my age
The numbers on the clock 123456789 10 11 12
The number on my ruler is 12
9 Thats my brother's age
40 is my mother age
43 is my father age"

Alice had additional ideas about number usage

"107 Room number
529547 licence number
7 my age
208 my brother's room number
3 my sister's age
9 my brother's age
26 milk money
5 days in the week for school
8-o'clock my bed time
3-o'clock we get out of school
15 our spelling test
5¢ to get on the bus
13¢ to get on the street car
5¢ for a pare of scissers"

Ralph expanded the items mentioned by the other two pupils with the following:

"15 Posttill zon number
June 19 Father'S day
May 9 Mother's day
Ab-4-5644 Father's business phone number
8 letters in the word entrance
5 letters in silly
20¢ two dimes"

A comparatively large number wrote of obvious and frequently used number situations

28 pupils mentioned their school room number
19 correctly wrote home addresses, or as one pupil termed it, "my number at home"
17 gave their telephone numbers

19 gave their ages in years; 3, their birthdate
12 wrote ages of family members
11 were aware of the 20¢ admission price to the school show
14 wrote the numbers of inches on their rulers
10 gave their brothers, sisters and friends' room numbers
4 wrote, "2, the number on my pencil"
3 pupils referred to 24 crayolas in their boxes; 4, to 16 crayolas and 1 said, "8 crayola colors"

Some additional items mentioned by individual pupils were:

"100 I got on my spelling"
"5 rooms in our old house 7 in our new"
"25¢ a quarter 1 penny 5 penneys a nickle"
"53 my weight"
"3 books on my birthday"
"4 storys on the board"
"11 to spell Mississippi"
"100 in numbers is good"
"3 cashgens in the morning paper"[3]
"5¢ a number of money 6¢ more money"
"105 the number under my chair"
"5¢ for a popscil"
"2 number of my friends"
"$71 in my bank"
"6x my dress
"3 goldfish"
"6 o-clock supper time"
"3-1-1 go out for fire"
"1 2 3 4 5 6 7 8 9 10 some numbers
1 2 3 4 5 6 7 8 9 10 11 12 13 14 more numbers
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 lots of numbers"
"9 o'clock I go to school"

One pupil's factual approach was:

"I have 38 pennies at home. I have one father.
I have 5 good friends. I have two good books.
I have one pen at home."

Three pupils wrote numbers on their papers with no attempt to associate them with number situations. The background and general achievement level of these three pupils would indicate their inability to understand the assignment or to carry it out without particular help from the teacher. Data could perhaps have been secured in a personal interview with each pupil.

We are not to conclude from this study that the pupils' written statements represent their entire knowledge of how numbers function in their lives. Their writing and spelling abilities as well as powers of concentration impose limitations. It is not to be assumed, for example,

[3] "cashgens in the morning paper" refers to the pupil answering questions related to the story in the text read that morning.

that all pupils who omitted mentioning their street numbers or ages did not know them.

However, the simple study furnishes some interesting data. Even at their young ages, the first graders are immersed in a stream of figures; book page numbers, shoe sizes, dress sizes, numbers on their pencils and on their chairs, spelling scores and clock time. They use numbers to read a bank account, to go to the movies, to buy popsicles. They know the date of father's day, mother's day and their own happy birthday.

Those who have taught first grade know of the difficulty adults have in recapturing the pupil's viewpoint so that numbers may be related to the experiences of the pupils in a culture that is highly quantitative. But when it is done, teachers are rewarded with results such as is indicated in the exercise described in this paper. The pupils, who knew the licence number of their family car, had this information as a result of participating during the semester in a unit of work based on their experience with this specific number situation. They had shared the excitement of a fellow pupil whose family car had disappeared from in front of the family home. They had heard the details of the recovery of the car, which had been stolen, abandoned and traced to the owner through the license number. As a class project the pupils had made cardboard duplicates of the license plates on their own, relatives or friend's cars. Situations in which license numbers showed ownership and helped identification were discussed and dramatized.

It appears obvious from the written statements of the pupils that they are beginning to be aware of the use of arithmetic as a tool to enrich their personal objective experiences and to help them handle their world. The number 107 on a school room door operates to direct certain pupils to turn in at that door for the day's work, while their brothers, sisters or friends move on to another classroom door with another number. A place at "table 2" or "the first seat in the third row" gives the security of having "my very own place." The little one, who would have trembled with fear at the sound of an unusual loud noise in the school has learned through number that the fire bell ringing three times, followed by two more rings and a final two rings is a guide to his actions in participating in an orderly drill.

Number knowledge has linked the pupil with home, family members, and relatives. He basks in the knowledge of his address, telephone number, father's business telephone number, grandmothers and auntie's number. This knowledge gives him a sense of comfort and well-being, the elements of security which we want every child to have. The thread of boy and girl friend and best friend runs through the pupil's accounts of their use of numbers. Number knowledge of

their ages, telephone numbers and addresses serves as a link in these relationships.

The need of the six year old to know that Channel 5 and not Channel 8 will bring to him the glories of a televised puppet show is of vital significance to him. His needs are being as surely met today by arithmetic as were the needs of the Egyptians in the days when the overflowing of the Nile washed away the landmarks showing the division between one owner's field and that of another and it was discovered that the shadows of the pyramids black and sharply defined on the sand could be used as permanent and irradciable landmarks.

Heartening though it is to find that the child of primary level has an insight into numbers as they assist him to meet his needs in a variety of situations, there is another phase of appreciation which must begin to be sensed by the child. This is a realization of the manner in which numbers operate throughout the universe. I am not suggesting that a child of this age can comprehend in any intelligible way this law and order which arithmetic holds in common with the entire cosmos. However, I am convinced that unless the teacher has this appreciation, the teaching of arithmetic suffers. Lacking this appreciation, her viewpoint will be colored, even though perhaps no one can specifically point out its reflection in a single sentence or action.

The teacher of primary arithmetic, who has a rich background for the simple material she is using to teach number has an artist's appreciation. How much do we know of the rich lore of the absurd jingles we use to teach number? Do we appreciate that children's rhymes show the stages through which man passed in learning to count? We note his laborious struggle to count to five on the fingers of his hands and the difficulty in envisioning numbers beyond 5 in the rhyme:

> One's none,
> Two's some,
> Three's a many,
> Four's a penny
> Five's a little hundred.[4]

Today our First graders stop at five before going on to ten in the rhyme:

> One, two, three, four five,
> I caught a hare alive,
> Six, seven, eight, nine, ten,
> I let her go again.

Again, we see the base of ten:

> One, two, buckle my shoe,

[4] Henry Bett, *Nursery Rhymes and Tales*, New York, Henry Holt and Co., 1924, 48.

Three, four, shut the door
Five, six, pick up sticks
Seven, eight, lay them straight,
Nine, ten, a big fat hen.

As she sings the rhyme of the four and twenty blackbirds baked in a pie with the children, the first grade teacher thinks of the romance of its history and how deeply the rhyme is bound up in tradition. She smiles as she thinks of the 16th century practice of concealing surprises in pies and the particular 1598 recipe which suggested how a pie could be made so that birds might remain alive and fly out as the pie is cut.

Appreciation of arithmetic can come to the teacher if she will study the order, law and beauty of the world. Jay Hambidge in his *Dynamic Symmetry* tells us that beauty is the order which can be expressed in the cold intellectual symbol of the mathematical formula. Looking at a vase, one may see it as a thing of beauty, but mathematicians will show that the beautiful harmonious curve so satisfying to the eye is that which is best expressed in a mathematical equation. The beautiful arches of a bridge are the design, not of artists but of mathematicians. Teachers who see and appreciate can better prepare others to appreciate.

In summary, we may say that as early as in the first grade the pupils can began to appreciate arithmetic. From the use of numbers in a wide variety of situations will come the gleanings, however faint, of the value and significance of arithmetic. The teacher's appreciation will contribute to the richness of the pupil's appreciation.

You remember Alice of the classic, *Alice in Wonderland*, working a sum and handing it to Humpty Dumpty. His judicious approval, "This seems to be done right," elicited Alice's startling reply, "But you're holding it upside down." Our pupils may be looking at arithmetic upside down—doing it, but not appreciating it.

THE NEA ON A NATIONAL BOARD OF EDUCATION

The Association believes that the development of education, whether at the local, state, or national level, should be placed above all temporary and partisan political issues and provided with appropriate administrative arrangements to safeguard the integrity of the educational process.

To this end, the Association again urges Congress to create a National Board of Education as an independent agency to administer the United States Office of Education. The members of the National Board should be appointed for long overlapping terms by the President with the consent of the Senate. It further recommends that the National Board should select a professionally qualified Commissioner of Education who would be responsible to the board for the conduct and performance of the office.

INSIDE THE ATOM

I. BEFORE THE ATOM WAS SPLIT

BARBARA R. BALZER*
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Ever since men have been thinking, they have wondered about what the things they saw all about them were really made of. The early Greeks knew, of course, that they called the stuff from which their furniture was made "wood," and that they built their temples from blocks of stone, and made their pottery from clay. But they wondered, if they broke up the pottery into smaller and smaller bits of clay, and the stone and wood into smaller and smaller pieces, how small they could make the pieces and still have pieces of stone, wood, and clay. They wondered whether the smallest pieces of stone and wood would be exactly like the smallest pieces of clay.

Democritus was a man who lived in Greece about two thousand five hundred years ago. He did not even try to chip pieces of stone, or to break pieces of clay to discover the smallest pieces possible. He merely thought about what kinds of pieces there were, and imagined how they must be. He called the smallest bits of things "atoms" from two Greek words meaning "not" and "cut." These atoms, he said, were many in number and took many shapes. They moved and occasionally bumped into each other.

Democritus could not prove anything about what he thought. The Greek people, living over two thousand years ago, did not have any of the fine measuring instruments we have now. Even today no one has been able to see anything as small as an atom. We have seen only signs that atoms exist, and to see those signs we have had to use many exact scientific instruments.

Two thousand years after the time of Democritus, men started to work with proper measuring instruments to prove that there were atoms, and that they were the smallest particles of matter. In 1804 an English chemist named John Dalton published his Law of Multiple Proportions. He called it a "law" because he felt that he had done enough experiments in his laboratory to prove without doubt that it was true. Two years later a Frenchman, Louis Gay-Lussac, announced his Law of Volumes. Both these laws could be explained in the simplest way possible by saying that all things are made of atoms. These atoms are small particles which can be grouped into a number of classes called elements. The members of each class, the atoms of a given element, are all alike in size and shape.

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Count Avagadro, an Italian, worked to determine the number of molecules, or combinations of atoms, in definite volumes of gases. Michael Faraday, another Englishman, worked on breaking up compounds, made of molecules, into separate elements by means of an electric current. The Irishman, Robert Boyle, compared pressure-volume relationships in different gases. These pieces of research added evidence to support the idea that atoms are the smallest particles and that all things are made of them. By this time most scientists believed in the atomic theory. No one had ever seen atoms, but Dalton, Gay-Lussac, Avagadro, Faraday, and Boyle had seen many indications that they existed.

When most scientists had accepted the atomic theory, the next question asked was: Are these atoms really the smallest particles or can they be broken up into smaller particles? Even some of the Greeks knew that sometimes when certain objects were rubbed with other objects, they had the power of making some substances move towards them. When a stick of amber was rubbed with fur, it would pull towards it little pieces of paper or fur. Later on, during Queen Elizabeth's reign, an English scientist called such an amber rod "electrified"—from an old Greek word.

In 1750, Benjamin Franklin realized that there were two kinds of electricity—one was the kind made by sealing wax or amber, and the other was the kind made by glass. He had noticed that the glass rod which attracted paper would push away bits of sealing wax if it were brought near them. Benjamin Franklin named these two kinds of electricity "positive" and "negative." He thought that a fluid, which no one could see, and which acted very quietly, was at work all over the world. It pulled all things to it, or *attracted* them, but it pushed little bits of itself away, or *repelled* them. Mr. Franklin thought that the glass grew hotter and became bigger when it was rubbed by fur, and that it could then hold more of the fluid. When he talked about "little bits" of fluid, Mr. Franklin meant that he thought the fluid was made of particles like atoms. He did not know, or try to find out, whether the particles were larger or smaller than atoms. His inquiry was, however, a step toward the theory that electricity is closely related to atoms.

Men grew away from Franklin's theory. They liked better the idea that there were *two* fluids, positive and negative, which weighed nothing. Matter which didn't show any signs of being electrified contained, they said, equal amounts of the two fluids. They called a body "positively charged" which contained more positive electricity than negative. A "negatively charged" body would then contain more negative electricity than positive.

In 1820 a man named Hans Christian Oerstedt first decided that

electricity had something to do with magnetism because when materials were electrified they behaved just like the magnetic pieces of lodestone found in the earth. When he sent an electric current through a copper wire, Oerstedt discovered that iron filings would line themselves up around it as though it were a magnet. If there was no current in the wire, it had no effect upon iron filings.

In England Michael Faraday tried passing a current from a battery through a solution by means of two plates sticking down into the liquid. If he used water with a little acid in it, the water would break up into two kinds of elements—hydrogen gas and oxygen gas. This process he called *electrolysis*. The hydrogen, Faraday discovered, would always collect on the plate attached to the same end of the wire. This plate is called the *cathode*. The current, according to the Franklin notation, always flows through the wire toward the cathode. Faraday found also that a certain amount of electricity passed through the water always deposited the same amounts of hydrogen and oxygen, regardless of the temperature of the water or the amount of acid in it.

This meant to Faraday that if the liquid were made of particles called atoms, and if each atom were alike, then each atom must carry one or more charges of electricity. This information did not agree with the theory that electricity was a continuous fluid. Scientists were forced to believe, because of Faraday's experiment, that, at least in electrolysis, electricity behaved as though it were atomic.

Johnstone Stoney suggested in 1874 that a fundamental charge of electricity be called *an electron*. He studied Faraday's experiments and arrived at a value for the electron. The value was computed by means of the relation between the amount of current that passes through a solution of some silver salt and the weight of the silver deposited at the cathode as a result of that current.

In 1887 Heinrich Hertz in Bonn, Germany, proved by direct experiment that electrical forces are carried from one place to another in the form of electric waves which travel through space. Maxwell proved that the speed of travel was the same as the speed of light. After this experiment many men of physics changed their opinions about electricity and decided that it was merely a strain in the ether.

For several years scientists tried passing electric currents through many different solutions and melted solids in order to decompose them. The theory of electricity was accepted by most scientists as an explanation of electrolysis, but was not held for other cases until the very end of the nineteenth century.

Scientists had wondered whether gases conducted electricity and, if they did conduct electricity, how to explain this fact. Before the discovery of X-rays in 1895, no one had solved this problem. Dr.

J. J. Thomson was directing research at the Cavendish Laboratory at Cambridge, England. Some of his students discovered that while the new X-rays were passed through a gas, that gas would conduct electricity. Thomson discovered that a gas which had been given the power to conduct electricity lost that power when the gas was sucked through glass wool. When the gas was drawn through narrow tubes, it was not able to conduct as well. When the gas was passed between two plates, one of which contained more electric charges than the other, it lost its ability to conduct electricity. The first two experiments showed that the conductivity was due to something that could be removed by filtration or by passing through metal tubing. The last experiment proved that this something had an electric charge.

Sir William Crookes had found that when two plates in a tube empty of air contained different amounts of electricity, a current flowed between them. He said that the current was carried by something called *cathode rays*. Jean Perrin showed that cathode rays carry a negative charge of electricity. He did this by making them swerve to one side by means of a magnet and directing them into a cylinder, where they charged an electrometer with a negative charge. (An electrometer is an instrument for measuring whether a charge is positive or negative.) Dr. Thomson carried these experiments further to prove that since the cathode rays were deflected by a magnet, they must consist of particles of material—electrons. R. A. Millikan even measured the charge on a single electron.

By the time this had been done, all scientists were quite ready to agree that electrons were pieces of negative electricity, smaller than atoms, and contained in each atom in definite amounts. The number of electrons in an atom depended upon what kind of an atom it was, what element it represented. It was known that pure elements were neutral, bearing neither positive or negative charges. Therefore scientists reasoned that there must be in each atom a unit of positive electricity for each unit of negative electricity, or electron.

There was work for two more men to discover how and where electrons fitted into the structure of atoms. These two men were the Englishman, Lord Earnest Rutherford, and Niels Bohr, the Danish scientist. Thomson and his associates had thought that the atom was like a bean bag filled with equal numbers of "positive" and "negative" beans, evenly distributed within the bag. We know that if we shot a B-B gun at such a bean bag, we would expect the bullets to be slowed down in going through the bag and, as a result of collisions with the beans in the bag, to leave the path they would otherwise have travelled. If we knew the size and weight of the bean bag and the

weight and speed of the bullet, we could figure out how much the bullet would swerve from the course it had been travelling.

Lord Rutherford carried on such experiments, using atoms for targets instead of bean bags, and particles called *alpha particles*, travelling at high speeds, for bullets. Rutherford thought he could calculate just how much his alpha particles should be deflected. He was very much surprised when the results of the experiment did not agree with his calculations. He found that most of his bullets swerved only a little, while a few of them were made to bounce almost backwards. The only way that Rutherford could explain his results was to assume that instead of being composed of a mass of positive and negative particles of electricity, the atom really had a very heavy small center with a shell of lighter particles quite a distance from this nucleus. Most of the atom, reasoned Rutherford, was empty space.

Rutherford's experiment led Bohr to make a theory of the atom which was considered so important that he won the Noble Prize for it in 1912. To Mr. Bohr, the atom looks like our solar system. The nucleus is large and heavy like our sun. It is composed of closely packed, positively charged, heavy particles called protons. The particles flying around the nucleus in set paths, at a great distance from it, are much lighter and have a negative charge. They are the electrons that we have been talking about, and they correspond to the planets in our solar system.

A proton is 1840 times heavier than an electron. Even so, protons can't account for the large weights of most atoms. In the nuclei of those atoms, said Bohr, there are particles made of a combination of a proton and an electron. These particles he called neutrons. A neutron weighs approximately as much as a proton because the electron attached to the proton weighs practically nothing.

A very simple theory, indeed—yet it took scores of men over a hundred years of experimentation to tell us this much. From Benjamin Franklin's two electric "fluids" to Neils Bohr's knowledge of electricity as involving the electrons in atoms is a long step. Scientists are able to accept Bohr's theory only because they have the evidence of precise scientific instruments, and only because scientists in all parts of the world have co-operated in sharing the results of their research with each other.

Bohr's theory of the atom explains most of the changes we see in chemical elements when they are brought in contact with other elements. It explains why solids, liquids, and gases behave as they do. The theory gives us a clue as to how it is possible to get energy from the nucleus of an atom. But that is another story. . .

PSYCHOSOMATIC MEDICINE

A COMMUNITY PROJECT

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Psychosomatic medicine. This term used by doctors and psychiatrists today concerns itself with the effect of the mind and the emotions on the actual physical condition of the body.[1] The full importance of this concept in modern medicine can be seen if you consider that two out of every three persons who go to a physician's office for help today are suffering from mentally produced illnesses.[2] Medical science must emphasize psychosomatic medicine today. The real job in mental hygiene lies with the community itself, however, not its physicians. Through publicity and mental hygiene courses the people should be made aware of the causes of mental diseases and shown effective means of averting these diseases.

Dr. Edward Weiss, professor of clinical medicine at Temple University, makes this statement concerning mental hygiene today:[3]

> In at least one third of all the patients who consult a physician no definite bodily disease can be found to account for the illness, and in another one third of all patients the symptoms are not explained or are out of proportion to any organic disease that can be discovered.

This should neither be interpreted as meaning that these people are not sick, nor that they are needlessly wasting their money, and the doctor's time. Nor should we feel that these people do not need help. True, they do not have any organic pathological condition that would be revealed by scientific instruments, but they have just as much real pain as the patient who is diagnosed as having a pathological condition. These "imaginary diseases" present a bigger problem to the doctor than the organic diseases which can be cured by one of our new miracle drugs. The doctor must recall that illness is not always the immutable effect of some cause, but rather the outcome of a process of development in which innumerable factors play a part, particularly emotional disturbances.[4] He must realize that the industrial revolution has not been without an effect on the individual man. It has caused emotional anxieties and tensions which because of restrictions by society cannot be expressed in words or actions. They, therefore, express themselves in an organ language in the body.[5] This organ language may not cause a pathological condition right away, however, it does produce a sensitiveness in the organ and real

[1] Hannah Lees, "Sick of What?," *Colliers*, 116 (Dec. 8, 1945), p. 80.

[2] Frank G. Slaughter, M.D., *Psychosomatic Medicine*, p. 1.

[3] Lydia G. Giberson, "The Country Doctor Comes Back," *American Magazine*, 143 (March, 1947), p. 18.

[4] Carl Binger, "The Meaning of Psychosomatic Medicine," *American Scholar*, 15 (Oct., 1946), p. 79.

[5] Lees, *op. cit.*, p. 79.

pain. This is why a complete physical check up must be given the patient. If the doctor's examination reveals a sound body, then the problem becomes more complex to diagnose as to the exact cause and the most efficacious remedy for the ailment. Only within the last ten years have doctors freely recognized that a sound body is no assurance of a sound mind.[6] Behind the symptoms reported by the patient the doctor must now search for an emotion or set of emotions which has set off this organ sensitivity.[7]

The psychosomatic approach to medicine relinquishes none of the techniques of medical practice, but requires the doctor to consider the patient in two ways, physically and emotionally.[8] Even in patients where organic trouble is found the emotional side cannot be ruled out. Dr. Frank R. Drake, psychiatrist at the University of Colorado Medical School states:[9] "Doctors who are concerned only with the organic side of medicine can actually prolong a patient's illness indefinitely."

Psychosomatic experts are now convinced that high blood pressure which you can measure, asthma which you can see and measure, and ulcers which may have to be operated on can, but not yet must, develop from a deep seated and long lasting emotional tension. This tension can wear on the body until it actually causes physical changes.[10]

Tension, then, is where most of our illnesses today begin. As yet we have no patent medicine which claims to be an all tension vanisher. Tension removal is the job of the doctor today. Prerequisites on the part of the doctor are human warmth and understanding. With these qualities he must be able to gain the patient's complete confidence in order to aid the patient in self analysis which usually requires professional assistance.[11] When the emotional tension is found the physician should help the patient to see the insensibility of the matter and aid him to direct his emotional energies into different and more constructive channels. People can be cured of emotionally caused ailments by doctors who accept them as individuals rather than flesh and blood machines.[12] "It isn't what happens to the paitent but how he feels about it that counts."[13]

The chronic diseases which have responded to psychosomatic treatment are peptic ulcer, hypertension, hyperthyroid, and colitis. These diseases are usually found in a definite character type of per-

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[6] "When Mind's the Matter," *Newsweek*, 32 (Dec. 13, 1948), p. 46.
[7] Binger, *op. cit.*, p. 421.
[8] Giberson, *op. cit.*, p. 101.
[9] Frances V. Rummel, "Can Our Doctors Do More?", *Womans Home Companion*, 75 (Dec., 1948), p. 39.
[10] Lees, *op. cit.*, p. 80.
[11] Donald G. Cooley, "Your Emotions Can Make You Sick," *Better Homes and Gardens*, 23 (June, 1945), p. 90.
[12] Giberson, *op. cit.*, p. 95.
[13] Cooley, *op. cit.*, p. 17.

son.[14] Rheumatism, diabetes, respiratory disorders, migraine headaches, skin ailments and arthritis are also responding favorably.[15]

Medical science has made great progress in curbing contagious diseases since the nineteenth century. Preventative measures will no doubt someday completely annihilate them. Still the national morbidity rates have not dwindled to the small numbers they should with contagious diseases controlled. Mentally produced illnesses have not yet been conquered. Our real hope for the immediate future lies with the doctor's ability to recognize the emotional causes of functional ailments before the patient has been suffering with them for years. Right now our physicians must take care of the victims of emotionally produced diseases. The elimination of this category of diseases could more probably be achieved by the education of the people.

Corrective measures alone are not adequate in the field of mental health. If we are to conquer disease rather than go around in a vicious circle of "parents visiting their sins upon their children even unto the third generation" we must educate the people in mental hygiene.

A partial picture of the need for psychiatric treatment to the general public is portrayed by the fact that 16.6% of all men examined in our induction centers as of June 1, 1944, were rejected for personality difficulties. These 701,700 men were rendered unfit by situations which definitely are avoidable.[16]

The federal government began its campaign July 3, 1946, with the presidential signing of the National Mental Health Act.[17] This act proposes to vanish lack of knowledge of the causes of mental illness, lack of trained personnel, lack of mental health services and, most pertinent to each one of us, lack of public interest and understanding. If the public shows interest in mental health the other three aims can be accomplished more readily.

The United States Public Health Service as the administrator of the Congressional bill is trying to arouse the public interest by pamphlets, articles and other media to disseminate information on mental health.[18] Many states have programs similar to the one sponsored by the Michigan Society for Mental Hygiene. This Society conducts biweekly lectures on different aspects of mental hygiene. It also has a Saturday morning radio program. Films, posters and other visual education methods could also serve to aid the public in understanding mental diseases. I am not speaking merely of the mental diseases

[14] "Your Favorite Disease," *Science Digest*, 24 (Nov. 1948), p. 37.

[15] Milton L. Zisowitz, "Report on Psychosomatic Medicine," *American Magazine*, 64 (Jan. 1947), p. 50.

[16] United States Senate Committee on Education and Labor, Subcommittee Hearings, Part 5 (July 10-12, 1944), p. 1634.

[17] Robert H. Felix, "The Battle is Joined," *Survey*, 83 (Sept., 1947), p. 236.

[18] *Ibid.*, p. 236.

which must be institutionalized but all mentally produced diseases as ulcer, hypertension and others.

The goal of those now in mental hygiene work is that someday every community will have access to an all purpose mental health clinic, either stationary or transient, but available to the entire community.[19] The ways in which such a health program may be initiated are various, although they usually begin with the most pressing communal problems. Special needs of a community may range from the need for a child guidance clinic to psychiatric guidance in schools or courts. A community may start a marriage counseling center which could be valuable in decreasing the incidence of psychological difficulties in the husband and wife, making certain of their compatibility beforehand. Mental hygiene discussions could be held in schools and colleges. The community should not be satisfied at having a few of these services available but it should proceed to formulate a program which satisfies all the mental health needs of the community.

We now have national, state, and local organizations for mental health. The cooperation of the societies within themselves is necessary so that there will not be a loss of expenditures by repeating work.

The success of a mental health program depends upon the utilization of the knowledge placed at the disposal of the people. Any mental health program should be aimed at the parents if we are to stop psychosomatic diseases before they start. The doctors, teachers and social workers are not able to prevent the future generation from being afflicted with a psychosomatic disease. They can only catch it, arrest its further development and cure it if the person has not been afflicted too many years. Our prevention then must come from the parents. The two aims today then in this field should be to help the people who are now suffering from it and secondly to educate our people so that they will not spread the disease any further. The National Mental Health Act is laying a much needed foundation for mental hygiene both for today and for tomorrow.

Psychosomatic medicine should definitely be practiced by physicians. Two-thousand years ago Plato wisely reached this conclusion,[20] "Neither ought you to attempt to cure the body without the soul . . . for part can never be well unless the whole is well." Man is not a fortuitous collection of organs but an individual. Our hope for decreasing the number of mentally produced ailments appreciably is to educate the people as to the effect the mind can produce on the body when it is stimulated in the wrong channels. Better health can be attained if our people practice mental hygiene.

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[19] *Ibid.*, p. 237.

[20] Giberson, *op. cit.*, p. 16.

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ORLEANS SCIENTIST VISITS EINSTEIN

Our Science Demonstrations editor, Julius Sumner Miller, had the very unusual experience of a short visit with Dr. Einstein at his Princeton home during the summer. Mr. Miller has been a student of the great physicist's theories for many years and is a collector of everything he can get about Einstein. At this visit Dr. Einstein took Miller to his office and gave him a set of his important writings.

WOODEN MODEL FOR QUADRILATERALS

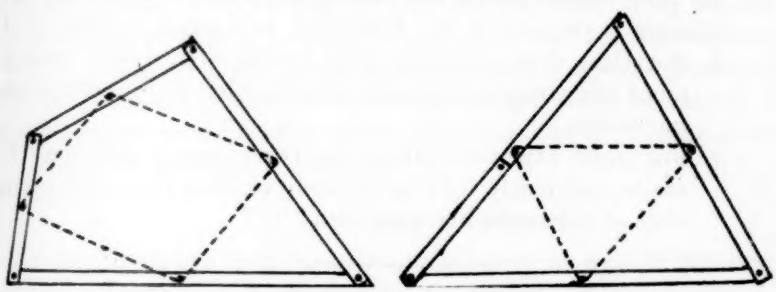
ETHEL L. GROVE
1814 Tuxedo Avenue, Parma 29, Ohio

I. Construction

A. Materials

1. Four 3/4″ strips of very thin wood or $\frac{1}{4}$″ plywood. (May be obtained from Industrial Arts Department or model airplane shops, or lightweight yardsticks may be used.)
2. Tacks or small nails, depending on thickness of wood used.
3. Two large rubber bands or elastic cord.
4. India ink and speedball pen.

If wood is not available heavy corrugated cardboard and paper fasteners may be used, but a model made in this way must be handled with care. If the teacher has no facilities for making a wooden model, there is usually some boy in the class willing to assist with it.



MODELS FOR QUADRILATERALS

B. Steps in Construction

1. Cut strips in any lengths that will make a general quadrilateral of convenient size for class demonstration. Strips in illustrated model are 6″, 8″, 12″, and 15″.
2. Form quadrilateral by fastening ends of strips with tack or nail. Use only one nail in each vertex but clinch it so that the joint is permanent but not rigid.
3. Drive tack part way through midpoint of each side of model and clinch it.
4. Join midpoints by rubber band or elastic cord. Two rubber bands may be cut and tied together if one is too short. (If rubber pulls figure into convex shape, hold model as desired and wrap rubber once around tacks.)
5. Letter vertices and midpoints with India ink.
6. By increasing the vertex angle between the two shortest

sides of quadrilateral to a straight angle a general triangle may be formed.

7. Turn model over and mark midpoints of sides of triangle with tacks as above.
8. Letter vertices and midpoints of sides of triangle.

II. Use

A. To demonstrate that lines joining midpoints of consecutive sides of a quadrilateral form a parallelogram.

1. May be used in class demonstration to show that although shape of wooden model is changed elastic figure remains a parallelogram.
2. May be made available for pupil experimentation and discussion before this theorem is introduced so that pupils can discover this relationship for themselves. (See "Models for Introducing Parallelograms" in the October issue for complete procedure for pupil experimentation.)

B. To demonstrate that a line joining midpoints of two sides of a triangle is parallel to the third side and equal to half of it.

1. For class demonstration turn model over, hold two-segment side straight, and stretch rubber band around triangle midpoints.
2. For pupil experimentation the two-segment side may be made sufficiently rigid by securely binding the overlapping ends of the segments with cord.

SHORTAGE OF ENGINEERS FORECAST

Recent reports received by the Manpower Committee of the American Society for Engineering Education show that large industries employing engineers have stepped back, during the last few weeks, into the market for engineering graduates, in spite of the large supply of engineers who entered the job market upon graduation in June. Except in a few areas nearly all of these June graduates have already been absorbed in industry, and serious shortages of engineering personnel in the near future are now indicated because of the expected increased need for engineers created by mobilization activities. The Secretary of Labor included all the principal fields of engineering in the list of critical occupations which he issued on August 3, 1950.

Although there is an immediate concern that the present supply of well qualified engineers may be inadequate, the outlook for the years ahead is still more serious, due to sharp reductions in the number of engineering graduates in prospect for the next five years or more.

THE NEA ON COMMUNISM

Members of the Communist Party shall not be employed in our schools. Communist organizations and communist-front organizations should be required to register with the Attorney General of the United States.

THE LABORATORY APPROACH TO MATHEMATICS

Weldon Sims and Albert Oliver
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"East is East and West is West; and ne'er the twain shall meet." But they have. A classroom is a classroom; a laboratory is a laboratory. Is there a common ground for their meeting? Consider, in this light, the laboratory concept.

Every good teacher of mathematics is concerned with the problem of making his course more meaningful. Psychological principles of effective learning are discussed from time to time, and many teachers reveal devices by which they feel they have engendered understanding. Yet it sometimes comes as a shock to a student in college mathematics to go out with various instruments in surveying and to realize for the first time just what many of the abstractions really mean. The obvious thought occurs—why have these experiences with objects instead of with abstractions been delayed so long? Why wasn't an opportunity to "learn by doing" presented with the introduction of various mathematical concepts in the secondary school? A number of the more effective ways to eliminate the necessity for raising such questions are bound up in a different approach to the usual classroom routine—the laboratory concept.

The Laboratory Concept

Most people are familiar with a laboratory as used in the natural sciences. Even though the famous Committee of Ten doubted the intrinsic value of the laboratory to the extent of declaring that time spent in one was equal to only one-half of that spent in the classroom, it has been a common experience of pupils to find that the learning was actually greater in this workroom. Through objectifying ideas and principles, through demonstrations, through participation in various experiments, and through opportunities to gain skill in types of manipulation, the learners are able to give meaning to verbalisms. Why should these same learners be denied a similar opportunity to find life in mathematics as a system of ideas? Just as the learner has found greater significance in seeing the amoeba as a living organism under the microscope, so also will he see "come to life" the vernier-as-an-instrument-for-measuring when he has a chance to use a vernier in actual measurement.

To some such an approach may smack of "softness," of inefficiency. After all, there is much traditional ground to be covered. The topic of what is educational efficiency is a matter for lengthy discussion in itself. Let it suffice here to point out that there is a growing conviction

that more attention must be given to outcomes other than the acquisition of facts alone, that presentation by the textbook procedure alone does not produce these important learning outcomes, that the increasing complexity of the secondary school population requires more attention to learning through multiple approaches. In short, a change in the learning environment, changes in curriculum organization, and changes in method of presentation are very much needed if mathematics is to be meaningful. It is the thesis of this paper that, in keeping with the old popular song, "There'll be some changes made."

For example, one reason for so much difficulty in learning mathematics is the verbalistic quality of the usual teaching. Verbalism is the use of words without emphasis upon meaning. It is little wonder that such teaching produces schoolboy boners such as, "Parallelepipeds are animals with parallel feet," or "The Colosseum was epileptical in form." Imperfect and vague concepts are the usual outgrowth when teachers require pupils to learn various formulae and theorems without attempting to teach them for understanding.

Then, also, teachers too often do not try to develop their courses by appealing to the interests of the learners. The teacher sees mathematics as a highly logical system of ideas. To him, with his greater maturity, experience, and background in mathematics, the logical is probably psychological, but he overlooks the fact that the logical may not be psychological for the beginner. Understanding comes out of interests, among other things. Adolescents like to investigate, to manipulate, to have ideas visualized. Emotional satisfactions are important to learning, and it goes almost without saying that an important role of the teacher is to utilize existing interests and to create new interests in the work at hand. However, for most learners the approach is not effective when it is centered in a rigorous presentation in a you-repeat-the-text atmosphere.

Finally, there is a common tendency to talk about individual needs and abilities but to feel that little can be done about it in mathematics beyond grouping or by two- and three-track plans. Certainly a teacher can find little time for individualization of instruction (although he may be aware of the fact that it is the individual and not the group that learns) if he relies solely upon a question-recite technique. What he needs is a method that will allow him time to provide for individual differences within the class period.

Would a mathematics laboratory help hurdle these barriers to effective learning? Some answer to this important question may be attained only after a thorough understanding of the meaning of "laboratory" in connection with mathematics.

It must be realized that the laboratory concept as here referred

to is more than a physical environment. It is an ***atmosphere*** in which problems may be worked out realistically, and in which real problems may be solved through the medium of mathematics. It is an ***approach*** to the solution of problems, incidentally mathematical in nature. The same approach may serve for the solution of problems in other areas. Science has always used such an approach, but because of its nature it has lent itself as well to the physical laboratory. To most people, therefore, the word "laboratory" conjures up a vision of a room with a demonstration table, numerous work benches, some wall charts, and an array of different types of apparatus. The physical limitations of a school building make the impracticability of setting up *special* mathematics laboratories fairly obvious. There is already too much overcrowding, and several such special rooms would be required to serve the average size mathematics department. And one separate laboratory would not be feasible since it would not be available to more than one group at a time, thus restricting the basic requirement of flexibility for a true working atmosphere, and utimately resulting in as artificial a situation as that in the traditional classrooms. This is not necessary. The contention of this article is that ***every mathematics classroom can and should be a type of mathematics laboratory.*** Include, as much as possible, wall charts, movable chairs which may be arranged in groups, mathematical instruments and models, supplies such as rulers and compasses. But above all, let it be remembered that the atmosphere established is the basically important thing, that realistic working conditions must exist, that an interest in finding the solution must be created, that the absence of fancy expensive instruments need not be a deterrent to the desire to find the solution and satisfaction in finding it through various "home-made" methods.

It is, to reiterate, a concept, an approach, and as such the laboratory approach in every classroom does offer many opportunities of advantage to any teacher—good or mediocre.

The Setting

On the assumption that a regular classroom as well as a special room can present a laboratory-for-learning environment, what aids can be mentioned to help develop that atmosphere? Lists of materials have been compiled before by writers on mathematical aids. Articles in *The Mathematics Teacher*, in School Science and Mathematics and in "Mathematics at Work," the report of the eighth Annual Mathematics Institute at Duke University, enumerate various instruments and articles. It would remove some of the thrill, hamper the basic experimental attitude to present a prescribed list of items as

"musts" for the laboratory environment, but most teachers would probably consider the following categories and select and then adapt in terms of the purposes of the particular course, the nature of the pupils in each class, and the projects under consideration:

1. Models—some prepared, but the most effective will be those developed by the pupils themselves. Various solids such as a spherical blackboard, conic sections.
2. Visual Aids—film strips, slides (class made), projector for movies to be borrowed, rented or purchased. Consider three-dimensional drawings to be used with special glasses worn by the observers. (18th Yearbook basic for the teacher here and in other aspects of the multi-sensory aids.)
3. Library Materials—supplementary texts in mathematics, astronomy, physics, navigation, and other arts and sciences making use of mathematics. Current magazines of wide variety. Pamphlets such as Guidance Pamphlet in Mathematics of the Post-War Commission. Books revealing the role of mathematics in the growth of civilization (including biographies). Books of mathematical games and recreations. Files (with pupil contributions) of clippings, jokes, pictures of mathematical import.
4. Wallboards—the usual "black" board with some cross section ruled spaces for graphs; sections suitable for thumbtacking posters, clippings, pupil projects.
5. Blackboard Tools—meter and yard sticks, colored chalk (special emphasis), blackboard compasses and protractors, 30–45–60 right degree triangles, T-squares.
6. Instruments of Applied Mathematics—slide rule (large for demonstration purposes), balances, pendulum, surveying equipment, pulley-lever-gear machine, and numerous other items culled from the learners' environment.
7. Construction Material—an endless field for a "new world" of mathematics created from bits of string, wood, cardboard, plastic, metal to challenge the ingenuity of the participants in curve-stitching, in linkages, in model building, in making "machines" to demonstrate mathematical laws. Eyelets, punches, glue, scissors, razor, etc.
8. Teacher Aids—workbooks and worksheets. These have certain limitations but serve practical purposes for some learners—especially for the maintenance of skills and for attention to remedial work. (Strathmore Plan) Resource units. (See Jones, Grizzell, Grinstead, *Principles of Unit Construction*, McGraw-Hill, for help on the unit approach. Also valuable is Thut and Gerberich, *Foundations of Method for Secondary Schools*, McGraw-Hill.) Innumerable devices such as a home made, demountable parallelogram.

Many teachers glancing at the above skeleton guide will note that they already use much of the materials and devices. However, it is the rare classroom that incorporates all these into a laboratory atmosphere, and the writers have visited many a mathematics classroom where one standard text, a blackboard, chalk are the extent of learning aids. Erase the board, hide the texts and it would be impossible for a newcomer to tell for what class the room was being used. Such is not a room permeated with the laboratory concept. Where are the materials that range from apples to clinometers? Where is the equipment that will help make the inert terms in the text come to life?

Organizing learning experiences

The laboratory concept is more than environment, although it should be noted that it does not restrict the class to a regular room or to a special laboratory. Indeed the community is a part of the learning laboratory. In short, one with the laboratory concept makes as a primary concern the discovery and utilization of community resources. (Note: community-relatedness is not restricted to field trips as some teachers have believed.)

Fundamental also is the organization of subject matter which seems to provide for as many types of activities as possible. It is not the purpose of this article to discuss the psychological advantages of presenting material through significant units, but it is important to note that the day-by-day, page-by-page assignment should give way to long-range assignments incorporating a wide variety of suggested activities. At present the general mathematics field offers greatest opportunities along this line, but if the approach is helpful to the learner, the more traditional offerings should be reorganized to make the best use of the psychological advantages of units. Especially valuable for a working environment are resource units from which materials may be "pulled" as the occasion demands.

Indeed, there is always the danger that activities will deteriorate into haphazard busy-ness unless all are pointed at a significant outcome; so the unit approach is vital for giving direction to the laboratory projects. As such the teacher needs to spend some time and thought in preplanning. Some phases of this are fertile areas for pupil suggestions and thus further the meaning of the problem through participation by the learners. This and the determination of pupil weaknesses and strengths (identified through various methods of pretesting) form the basis for the introductory stage or presentation. Here the teacher outlines the unit to the pupils, indicating the important outcomes expected and working out ways by which contributing problems can be set up and worked out. This preview may take a few minutes or several days depending upon the nature of the unit, the degree to which it is related to previous work, and the interest and understanding of the group. This is essentially a period of motivation and identification of tasks.

After the unit has been introduced and the students have a clear idea of the purposes of the unit, the laboratory period begins. Here countless activities are organized to make use of worksheets, drawing materials, reference books and magazines, models and construction items. The key to the success is to organize and suggest activities (and they do not all need to be physical activity) that will make use of a variety of senses and will be of various levels of complexity

and difficulty so that each learner will have some challenge to his particular ability.

Consideration also must be give to the evaluation process. This does not imply a lot of activity followed just by a formal test; there are a number of ways (including the summary test) by which both the pupils and the teacher can become aware of the direction, the extent, and the nature of the individual's growth relative to the desired outcomes.

Perhaps it is hardly necessary to repeat a caution which should be given about any different approach in education. Some go overboard for a new idea and then experience failure. They blame the new approach when often the ineffectiveness stems from the lack of careful preplanning by the teacher and from the failure of the teacher to prepare her class for a new learning venture. After all, a sudden switch from a teacher-dominated, all-follow-text-together routine leaves them as well as the teacher without security. Guides and controls need to be worked out. (An excellent account of practical techniques may be found in Gertrude Noar's *Freedom to Live and Learn*, Franklin Publishing and Supply Company, Philadelphia.)

Then, too, many teachers will point out that their particular course does not lend itself to units of adaptation nor to activities other than the formal mastery of skills. It is true that many existing courses are so organized that the pall of mental discipline hangs heavy over the classroom along with real or fancied dictation from college requirements. However, this does not preclude teaching for understanding, for attempting to make the class work meaningful. Even the teacher who dares not have his class move from their seats nor believes in having the members work on different assignments can overlook the advantages of stressing the many applications of mathematical skills, problems, and principles. Numerous mechanical aids can be employed to objectify the mathematical abstractions. He should at least operate with some time given over to supervised study in a room outfitted with mathematical reference materials, posters, clippings, pupil contributions so that the whole room takes on an atmosphere of living in a world of mathematics. Perhaps we need to go to the art people, to the advertising agencies, to the audio-visual aids experts to have them show us how to use the resources of our classroom-laboratory to "sell" ideas to pupils who have hitherto been indifferent, confused, or just unaware of the tremendous possibilities hidden in the mysteries of mathematics.

CONCLUSION

It is the belief of the writers that the laboratory concept offers great opportunities for bringing many of these mysteries into the

light of understanding. Certainly a carefully developed approach can do much to make mathematical experiences real ones and to make concrete many abstractions. It presents at least two challenges to the teacher. First, he must be willing to be openminded and to recognize the psychological advantages of a different approach although he himself has built his teaching security upon another method. Secondly, if he is willing to try the challenge of the laboratory method, he must also be willing to work hard. The traditional approach is easier; the one suggested here requires more ingenuity, more thought to the learning processes. It can stimulate him to work harder, but when the plan is well carried out there will be an additional compensation from the satisfaction of knowing that the pupils have found greater and newer understandings in an important field of learning that for a long time has been imperfectly understood and cordially disliked by many. When does your laboratory for learning in mathematics open?

UNITY, A USEFUL CONCEPT

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The following notes deal with a few of the difficulties students of elementary physical science courses experience. In all fairness, the fact that their elementary concept of unity and the uses of it in arithmetic computations reflect upon their background in mathematics, which is still recognized as one of the three R's.

A most important number concept is that of unity. The understanding of this number is essential to all students and particularly to students of mathematics and science. There are some forms of unity that are very common and useful that will be given here.

First of all, it must be clear that unity has a peculiar property. If a number n is multiplied or divided by unity, the result is the number n. This is true for no number except unity. Now apply this property of unity to some common problems.

A frequently encountered problem is an addition problem involving fractions. This problem in its most general form takes the form $a/b+c/d$. Now to add these two terms it is necessary to multiply the first term by unity in the form d/d and the second term by unity in the form b/b. This gives the immediate results $ad/bd+cb/bd\equiv(ad+cb)/bd$. Of course, the student will ask how one knows to choose unity in these particular forms. The answer is that one must know what he is doing. That is, one must know that the unity must be

chosen such that the denominator for both fractions will be the same.

This is a simple process and when fully understood leads to easy computation in problems of the following nature. First, problems involving radicals as $1/\sqrt{2}$. It is customary to make the denominator rational in such numbers. To do this, it is necessary to use unity in the form $\sqrt{2}/\sqrt{2}$. Multiply $1/\sqrt{2}$ by this form of unity to obtain $\sqrt{2}/2$, and the denominator is rationalized.

In working with complex numbers, unity again becomes useful. In this field, it is customary to convert all denominators to real numbers. For example, the complex number $(a+bi)/(c+di)$ can be changed into the customary form by multiplying the number by unity in the form $(c-di)/(c-di)$. This yields $[(ac+bd)+(bc-ad)i]/(c^2+d^2)$. It is understood that in the above problem a, b, c and d are real numbers and $i=\sqrt{-1}$.

Another form of unity which is in common use, and often not fully understood, takes the form of 100%. Many times students say "To find what percentage 5 is of 20, one divides 20 into 5 and multiply the result by 100." This is a common error among college students. Of course, one does not multiply 5/20 by 100, but by 100% or unity. Here again, it is easy to see that a little attention paid to the fundamental concept of unity will eliminate these errors.

To be definite, one is not allowed to multiply any number by any number, except unity, if the result is to leave the original number unchanged. However, it can be clearly stated that equals may be multiplied by equals to obtain equal products. This last statement is an assumption which is often never stated until the student takes his first course in plane geometry. How about those students who never take plane geometry? Are they to be left ignorant of the foundations of arithmetic?

The items mentioned above are not demonstrated by examples. However, any teachers of arithmetic can surely supply any needed examples. These deficiencies are quite common in classes of science.

THE CHIPMUNK IS PHOTOGRAPHED

Scenes of a chipmunk awakening from winter hibernation, believed to be the first such shots ever made for an educational motion picture, are one of the features of a new film, *Animals in Winter*, released by Encyclopaedia Britannica Films.

The opportunity for the unusual scenes occurred when Lynwood M. Chace, world-famed specialist in animal photography, opened the chipmunk's nest in the middle of winter to photograph it in the comatosity of hibernation. Fooled into believing it was spring by the warmth of the photographic lights the chipmunk awakened and began to stir about. When the lights were turned off, however, the chipmunk realized its mistake and promptly went right back to sleep, Mr. Chace reported.

THE METHOD OF DIMENSIONS
or
THE NATURE OF PHYSICAL QUANTITIES

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Dimensional methods, if treated at all, are usually relegated to a single chapter in physics textbooks. As a device for establishing the *homogeneity of equations* representing physical events, they are uniquely elegant. As a tool for the *development of the equations* the method is eminently rigorous. Teachers at all levels of instruction should use the method since, in this writer's experience, students find it interesting, helpful, and instructive. The elegance of the subject will become more apparent, it is hoped, as the discussion proceeds.

The intention in this paper is severalfold: (1) To discuss the historical and qualitative aspects of the subject on an elementary level; (2) To show its application in one or more examples in establishing the *nature* of physical quantities; (3) To derive by the method one or more familiar mathematical expressions for physical events, expressions commonly referred to as formulas.

All gross mechanical occurrences in nature are related by mathematical relations of a more or less simple nature to the system of definitions or axioms contained in Newton's three laws of motion. The effort to coordinate all physical events, whether of rest or of motion, into a dynamical system, centers around the names of Galileo, Kepler, Huygens, and Newton—particularly the last named. Galileo recognized, as the result of experiment, that the velocity of falling bodies was uniformly accelerated with time, and although this result seems to imply the property of the inertia of matter, this was not explicitly recognized by him. Huygens and Newton recognized it and the explicit formulation in the law of inertia as a universal law was preeminently Newton's. The quantitative expression of this law in a restricted form is the expression defining force, $f=ma$, or, more elegantly, $f=m(d^2s/dt^2)$. In the system of mechanics thus created three factors are concerned, viz., space, time, and inertia (or mass). Each of these three was taken as being fundamentlly distinct from the others and as necessary for the examination and specification of the sequences of mechanical phenomena. Thus the fundamental measurable quantities entering into this basic equation descriptive of all physical occurrences are length, time and mass. All change in the condition of a mechanical body is accordingly expressible by appropriate combinations of these quantities. Later, when electricity and

magnetism came to be studied, other entities were introduced which (temporarily at least) are of a fundamental type.

Now the units employed for measurement in terms of these three fundamental quantities are defined in terms of simple convenient arbitrary standards, the meter, the gram, and the second. The unit of length is a purely arbitrary, convenient standard. When the meter bar was made, it was supposed to be one forty millionth the circumference of the earth through the poles. However, later measurements showed this value to be incorrect and the standard meter is now merely the length of a platinum bar kept under certain fixed but arbitrary conditions. Michelson later determined the length of the standard meter in terms of the wavelength of three lines in the spectrum of cadmium so that we possess a check on the standard should it vary. A further refinement is now available in the wavelength of a green line in the spectrum of a Hg isotope. The unit of mass was for convenience chosen in terms of the inertia of a cubic centimeter of water at 4°C., the temperature of its greatest density. The second is merely a convenient fraction of the mean solar day, $1/60 \times 1/60 \times 1/24$ of the meantime that elapses between successive transits of the sun across the meridian.

As is seen, the choice of our so-called fundamental units indicates that they are in no sense fundamental, but are merely convenient, or even chance arbitrary standards to use with our Newtonian system. It is not surprising then, to find that our real and probably truly fundamental units, such as the electron and the mass of the hydrogen nucleus, are expressed in peculiar odd ratios of our chosen units. Indeed, an excellent system of units could be built around the *mass* of the electron as unity, the diameter of an electron orbit as the unit of *length*, and its orbital period as the unit of *time!* We are accordingly committed to expressing all phenomena in physics in terms of Newtonian mechanics and ultimately in terms of these three arbitrarily chosen fundamental units in the cgs system. Leaving the units aside, we can, in general, express by Newtonian mechanics all phenomena in terms of length, mass, and time. As an example, for the space s passed over from rest in a given time t, by a mass m, under a force F, we write $s = 1/2(F/m)t^2$. This equation expresses a necessary relation between the magnitudes s, t, F, and m, and this relation depends in no way upon the choice of the unit of length, which from its very nature is quite arbitrary. If we take a different unit to measure the linear dimensions, the equation still describes the event. In other words, we cannot expect to alter the course of nature by measuring with a foot-rule instead of a meter stick!

To better understand what is meant here let us discuss the process of obtaining a new quantity in nature. When a new phenomenon in

nature is observed the practice is to deduce quantitatively the behavior manifested by means of controlled quantitative investigation, and to formulate the behavior in terms of mathematically expressed law. Numerous illustrations exist in the history of science and for example we may pursue Coulomb's investigation of the law of electrostatic force. In deriving the law Coulomb essentially proceeded as follows: he took two charges and actually studied how the force varied for the same two charges as distance alone was varied. Then keeping the distance constant he varied first the state of charge on one body and then the state of charge on the other. The numerical results or data were set down in tabular form and by analysis* the mathematical laws controlling them were deduced. These were then expressed in the generalized form of an equation. This procedure led at once to the idea that the force between the two electrified bodies depended inversely on the square of the distance and on the product of the two terms that varied with the electrical state of the bodies. These two electrical states, q_1 and q_2, then appeared in the deduced law as follows: $f=q_1q_2/r^2$. This being a NEW quantity in nature he was free to define it. Since it was a property of electrification he called it *quantity of electricity*.

The law governing a phenomenon being once formulated, and the new quantity in nature *defined* in terms of things measureable in the mechanical terminology based on Newton, the unit value of this quantity may easily be defined. Assuming the cgs system of units defined above, all that is needed is to solve the equation discovered for the quantities under simplifying assumptions, and to set the quantity as unity when each of the items in the defining equation is taken as unity. Thus, one would write $q_1q_2=fr^2$, and simplify it by letting $q_1=q_2$. Then $q^2=fr^2$ and $q=\sqrt{fr^2}$. Unit electrostatic quantity was therefore taken as that quantity for which $\sqrt{fr^2}$ equalled unity in the phenomenon investigated. Put into words the law then is the formal definition. This process of becoming familiar with a new concept in physics by means of the defining equation, and defining the unit in the manner outlined, should give a far clearer idea of the concept and of the unit, as it presents in concise mathematical form the relations involved.

Now in developing a science numerous such new quantities are found, and it becomes essential to relate and correlate them with each other. It is further useful, so to speak, to keep books when new quantities are found to make sure that things are really legitimately equated. Thus writing an expression equivalent to an energy equal

* The most elegant and monumental achievement of this kind of inquiry is Kepler's analysis of Tycho Brahe's enormous assemblage of data.

to something that is not energy would introduce obvious errors. Again some new quantities are derived under conditions where their nature is not obvious and it pays to establish their nature. To avoid possible mistakes we can check our new equations by analyzing them into the three fundamental elements underlying all Newtonian mechanics, that is, we determine the ***dimensions*** of a quantity in terms of length L, mass M, and time T. If the quantities on the two side of an equation have, outside of numbers or numerical ratios, which we ignore, the same *powers* of L, M, and T, the equations are dimensionally correct. By the same process we can determine the dimensions of a new quantity in terms of known ones.

An interesting elementary example at this point will serve to illustrate the usefulness of the notion. The equation $S=1/2\ gt^2$ is the expression for a physical event. We call it a formula. The above argument shows at once that the quantity on the right side possesses the properties of a length. That is, g is a length per unit time-squared; this multiplied by a time-squared reduces to a length, simply. Hence the equation is valid. We say that it is dimensionally homogeneous. It is now true also that $v=gt$ is a very good expression for a physical event. It is further true mathematically (that is, on the strength of mathematical axiom), that we can write $s+v=1/2\ gt^2+gt$, and this equation can be satisfied at every moment for a body falling from rest. Such an equation, however, never appears in the course of a physical investigation. It is in reality two equations with their terms intermingled and each of these equations is separately satisfied. If it is understood from the beginning that such an equation cannot occur, the complication in proving certain theorems is much diminished. Fourier recognized that if the equation is not homogeneous with respect to each kind of unit, an error must have been committed in the analysis or else abridged expressions must have been introduced. The implication here is that some of the apparently purely numerical factors must in reality represent physical quantities whose dimensions have been suppressed. For example, if we say that the fall from rest under the action of gravity is sixteen times the square of the time of fall and are thereby apparently equating a distance to a time-squared, the number sixteen is a brief way of saying sixteen feet per second-squared. Such abbreviations are often used, but their meaning is obscured. Students learn this in a parrot-like fashion without an understanding of its meaning!

Returning to this requirement of homogeneity, a word should be said on the method of naming the units. This is ususally done by beginners who proceed to *cancel* promiscuously so as to come out right! Teachers often insist that they carry along the units, and textbook writers illustrate it. This must not be taken as implying that we can

conceive of the operation of dividing, for example, a centimeter of length by a second of time. This is an operation which can only be performed with numbers. Thomson protested that "a second squared, the square of a second, and the second power of a second of time are all of them essentially meaningless conjunctions of words."

The dimensions of a few important physical quantities may be briefly considered here. The reader should establish for his own satisfaction that an impulse and a momentum, for example, are dimensionally identical, as are a kinetic energy and a work. The nature of Planck's constant h is interesting to examine. If we utilize the photoelectric equation, h times a reciprocal time (T^{-1}) is equated to energy. Hence h must have the dimensions of energy times time; erg-seconds, we say. Again, students rarely recogize the intrinsic meaning of the product PV, and they rarely give a satisfactory definition of temperature. It is easily shown that PV has the dimensions of work, and this detail, we suggest, is highly illuminating. Temperature begins to acquire a *physical* significance with the dimensional examination of $PV=RT$. We have shown that the dimensions of PV are ML^2T^{-2}, or energy. Hence RT is work or energy, and in fact the later development of the kinetic theory showed that RT is 2/3 the total kinetic energy of the molecules of a gas. Thus we gain an actual understanding of the nature of RT and hence of temperature, for T multiplied by R gives the energy in the gas at a temperature T, T being the scale factor of the energy content.

Another very interesting, important and illuminating illustration comes from electricity. In the electrostatic system quantity of electricity is properly defined as $q=\sqrt{fr^2k}$, where k, called the dielectric constant, is a new "constant" of the materials in which q finds itself. Parenthetically, k is not constant, since its magnitude is governed by the state of the material, the temperature, the pressure, the state of strain, etc. Further, we omitted k in the remarks above since it was discovered much after Coulomb's time by Faraday. We shall not be concerned with its dimensions, if indeed they are truly known. Accordingly $q_{es}=k^{1/2}M^{1/2}L^{3/2}T^{-1}$. In the electromagnetic system of units $q_{em}=it$, where i is the current and t is time. But i is further defined from Ampère's Law which says equivalently that $f=idsm/r^2$, where ds and r are lengths and m is magnetic pole strength. In addition, the analog to Coulomb's Law for electric charges defines $f=m_1m_2/\mu r^2$, where m is pole strength, r a distance, and μ the magnetic permeability, a property of the magnetic materials in which m exists. We shall not be concerned with its dimensions, if indeed they are truly known. Accordingly, m is defined by $\sqrt{fr^2\mu}$, which possesses the dimensions $\mu^{1/2}M^{1/2}L^{3/2}T^{-1}$, whereupon i in Ampère's Law takes on the dimensions $\mu^{-1/2}M^{1/2}L^{1/2}T^{-1}$. It follows that the product of i

and t has the dimensions $\mu^{-1/2}M^{1/2}L^{1/2}$. This, then, represents a quantity of electricity q in the *em* system. Now the quantities q_{em} and q_{es} should be dimensionally the same, for they represent *quantity of electricity*, differently named but believed to be the same. If these dimensional expressions are equated we have $k^{1/2}M^{1/2}L^{3/2}T^{-1} = \mu^{-1/2}M^{1/2}L^{1/2}$. This can hold true only if $\sqrt{1/\mu k}$ has the dimensions LT^{-1}. But LT^{-1} is a velocity. Thus $\sqrt{1/\mu k}$ must be a velocity. The question which naturally arises is: What does this velocity represent? The answer is amazingly simple. It is experimentally determined that 3×10^{10} electrostatic units of quantity are equivalent to one electromagnetic unit. This numerical ratio is the velocity of light in empty space in *cm/sec.*, i.e., in absolute *cgs* units. Hence $\sqrt{1/\mu k}$ might be expected to represent the velocity of an electromagnetic wave. *It was the discovery of this ratio which led Maxwell to investigate the electromagnetic relations and to deduce the fact that a wave motion in empty space was implied—a wave motion with the properties of light and a velocity* $\sqrt{1/\mu k}$. This was a monumental achievement in the history of physical thought.

Hence, by dimensional reasoning, coupled with experimental fact, we have arrived at a conclusion that, while sepraately, μ and k have indeterminate dimensions, in the form $\sqrt{1/\mu k}$ they represent a velocity. Indeed, this velocity is that of the propagation of electromagnetic waves through empty space, and the ratio of the fundamental electrical units is equal to the velocity of light in magnitude!

We turn now to a demonstration of the method of dimensions in establishing the mathematical expression of a physical law. We shall take as one illustration the case of the simple pendulum. This is indeed a very simple case in mechanics but it will suffice to bring out the elegance and rigor of the tool.

Let us specify first the various characteristics which distinguish this problem from others. We observe that the motion is periodic and hence we may wish to find the law which governs the behavior. The suspending string has a length l say, but let us take its mass as negligible. This assumption is acceptable, for later we will show that these initial restrictions may be removed and the case extended. The bob we will take as small but of finite mass m. This mass, we know, has a weight w by virtue of the Earth's attraction. For added simplicity we take the arc of swing as small, although again this restriction may be removed. We agree that we are introducing a number of restrictions which will need to be removed if the method is not to be defeated, but at the outset the problem would become too complicated if we dealt with these. The restrictions are quite legitimate. They are simplifying assumptions which are permitted in any first analysis.

The problem, then, is to find some relation between the periodicity,

the length, the mass, and the weight. That is, if t is a function of l, m, and w, we wish this functional relation. We write $t=f\ (l,\ m,\ w)$. Assume that each quantity enters as a definite power so that $t=$ constant $\times l^a m^b w^c$. Now t has the dimensions of a time simply; l^a involves a length a times over, or has the dimensions of a with respect to length; m^b involves a mass b times over, or has the dimensions of b with respect to mass; w^c has the dimensions of c with respect to a weight (or force). And finally, a force is a mass $\times$ an acceleration. The equation for the dimensions can thereby be written

$$T=L^a M^b (MLT^{-2})^c.$$

This is a formal way of indicating how these fundamentals enter into the problem. It is a step in the application of the principle of dimensional homogeneity. It shows at a glance that the left-hand side is independent of length and mass. Hence the right-hand side must be. Further, the dimension of time must be unity on both sides. Thus we are led to the following:

Considering length . . . . $0=a+c$.

Considering mass . . . . $0=b+c$.

Considering time . . . . $1=-2c$.

We have here three "unknowns" and three equations connecting them. The solutions are $c={}^{-1/2}=-b=-a$, whence

$$\begin{aligned} t &= \text{constant} \times l^{1/2} m^{1/2} w^{-1/2} \\ &= \text{constant} \times \sqrt{\frac{lm}{w}}\,. \end{aligned}$$

But Newton showed that

$$w=mg, \text{ and therefore}$$

$$t=\text{constant} \times \sqrt{\frac{l}{g}}\,.$$

The result is obviously familiar to the reader. The value of the constant can only be found from experiment or from the usual mechanical solution of the problem. If the relation between mass and weight were first postulated, that is, if the gravitational effect on the bob were represented by the acceleration g, the initial data would have been length, mass, and acceleration, instead of length, mass and weight. The same final result would have been reached.

In the pursuit of this investigation we have set down certain arbitrary restrictions for the purpose of simplicity only. We proceed to remove some of these. For example, we assumed a small arc whereas

on the evidence of experiment and mechanical theory the period depends to some extent upon the arc of swing, call it s. If, now, this arc is taken into account we must rewrite our first formulation as $t = \text{constant} \times l^a m^b g^c s^d$. Note that we have here written g^c rather than w^c which merely assumes that we now know the relation between mass and weight. Dimensionally, then, we write

$$T = L^a M^b (LT^{-2})^c L^d,$$

and proceeding as before with a consideration of homogeneity we have

For length .... $0 = a + c + d$

For Mass .... $0 = b$

For Time .... $1 = -2c$

This looks indeed troublesome since we have 4 unknowns and only 3 equations! These yield $c = -\frac{1}{2}$; $a + d = \frac{1}{2}$, whereupon we may write our original formulation as

$$t = \text{constant} \times l^{1/2-d} g^{-1/2} s^d$$

This may be written now as $t = \text{constant} \times \sqrt{l/g} \cdot (s/l)^d$ which form we can readily treat. For the fact is that s/l is a pure number and the power to which it is raised has no influence on homogeneity. Indeed, what is explicitly indicated now is clearly this: that it is not the arc s which influences t, but the ratio of this arc to the length l. In short, it is the *angle* that matters, for the ratio of s to l is indeed an angle in radians! As before, the constant is found from experiment or mechanical theory, as is the exact role played by the angle.

If, now, some of the other initially imposed restrictions are lifted, the problem becomes that of the physical or compound pendulum. It is left as an exercise for the reader to develop the analogous expression for the period of a physical pendulum, using the method of dimensions.

We have thus shown some of the more elementary aspects of dimensional methods. For simple cases we have assumed that the three quantities, length (L), mass (M), and time (T), are fundamental and sufficient. An extension of this subject would reveal certain dilemmas, for relativity theory and electrodynamics force us to question the nature of these quantities. Indeed, the very nature of mass is under the closest scrutiny, for mass and energy appear to be mutually convertible. We measure the *mass* of an electron, say, and conclude that its fundamental nature is that of mass. We now observe diffraction effects with these same electrons, effects discretely the property of wave motion, or radiant energy. There is, in truth, serious doubt whether mass is entitled to the place it has heretofore occupied in physical thought.

MATCHING GENESIS WITH GEOLOGY

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Probably there is no science teacher who has not at some time wondered himself, or been asked by his students, about the so called conflict between science and religion.

The conclusions reached on this issue have often been more emotional than rational. The true scientist and the true theologian, however, recognize that they are both in search of the same thing—TRUTH; and that truth can never be in conflict with itself. They will therefore calmly examine the evidence. Once the truth is known on both sides apparent differences disappear. As a matter of fact it is probably safe to generalize that where much is made of the so called conflicts, the proponents usually have personal axes to grind and there is more concern over trying to discredit the other side than over partnership of effort to resolve the differences.

History is full of examples of both sides going off half cocked, but not so well known are the less dramatic efforts of both scientists and theologians which have done so much to overcome the emotional conflicts which characterized the latter part of the last century. At that time certain groups and individuals were doing their best to use science as a tool, not for knowledge so much as an attempt to discredit religion in favor of materialism. Theologians, on the defense, went to extremes of their own. In modern days one seldom hears informed folk arguing over the "quarrel" between science and religion for it is generally recognized that there is no such quarrel. Intelligent folk will examine their own deficiencies before they leap into waters over their heads. Wise men will study and discuss, but they seldom argue.

This does not mean that in the lives of individuals there will be no honest questioning. Everyone goes through a time of life when a philosophy is being developed or destroyed, depending on the individual, his contacts and his approach. Honest questioning, followed by careful study and contemplation, are essential in the search for truth. But we must not be like Pilate who asked "What is Truth?" and then did not stay to learn.

This writer, with both a scientific and a religious background and a questioning spirit as well, has long pondered on the story of creation as related in Genesis compared to the same story as told by geology. After considerable reading and thought the following analysis was developed and is here offered as a small example of how science and religion can be brought into harmony.

In the beginning God created heaven and earth. And the earth was void and empty and darkness was upon the face of the deep. . . . And God said, "Be light made," and light was made.

These verses refer to the very beginning of all things using Heaven and Earth to mean the sum total of creation—space and matter. Astronomers tell us that in the beginning all matter was probably in the form of atomic or sub-atomic particles, without form or shape, spread through all the dark, cold emptiness of space. Then, for reasons unknown, the particles gathered together into units of vast size. These expanded outward, some say explosively. Each mass developed within it further condensation of the gases of which it was composed. These condensations contracted, compressed and ultimately began to glow to form the stars. At this point light appeared for the first time in the darkness of space. So Genesis in no way differs with scientific thought on this first phase of creation.

And God saw the light that it was good and He divided the light from the darkness. And He called the light day and the darkness night. And there was evening and morning, one day.

This refers to a view of the situation related now to the earth as a vantage point, with its rotation producing night and day. Nothing is said of the process by which the earth was created. Scientifically this is a reasonable description of what geologists claim must have happened in the *Archeozoic Era*. At first the earth, a glowing mass of incandescent gases of the sun from which it came, had no day or night in the sense of light and darkness. As the cold of space condensed the gases they rained down in a flood of lava to form the molten globe of the earth. Further cooling produced a crust upon the molten lava. Intense igneous activity, together with the lighter gases still remaining in the atmosphere, produced dense clouds. For ages of time the earth continued to cool until at length it ceased to glow and the heavy cloud mantle hid the sky. In time the temperature fell below the boiling point of water and the rains came, as all the aqueous gases condensed into water to form the first seas. Gradually the sky lightened but did not clear, for the earth was a steaming, misty, foggy place. Diffused sunlight could however lighten the daytime sky so that at this point the cycles of day and night might be said to begin, at least to be visible. It is this which the visionary describes in Genesis 4 and 5.

And God said: "Let there be a firmament made amidst the waters and let it divide the waters from the waters." And God made a firmament and divided the waters that were under the firmament from those that were above the firmament. And it was so. And God called the firmament heaven. And the evening and morning were the second day.

This second "day" seems to refer to the progress of events in the *Proterozoic Era*. The firmament refers to the atmosphere which then began to form. The rains continued in an ultra-tropical climate, with steaming oceans and a dense cloud mantle around the earth separating the waters below from the waters still in the clouds. The earth then was much as the planet Venus is now, perpetually shrouded by clouds. This situation continued on through the Proterozoic era into the *Paleozoic Era*. Science has some slight evidence of marine life starting at this time, but Genesis does not mention it, either because it was not visible to the visionary or because it is given emphasis later on as will be pointed out.

And God said: "Let the waters that are under the heaven be gathered together in one place and let the dry land appear." And it was so done. And God called the dry land earth and the gathering together of the waters He called seas. And God saw that it was good. And He said: "Let the earth bring forth the green herb and such as may seed, and the fruit tree yielding fruit after its kind which may have seed in itself upon the earth. And it was so done. . . . And the evening and the morning were the third day.

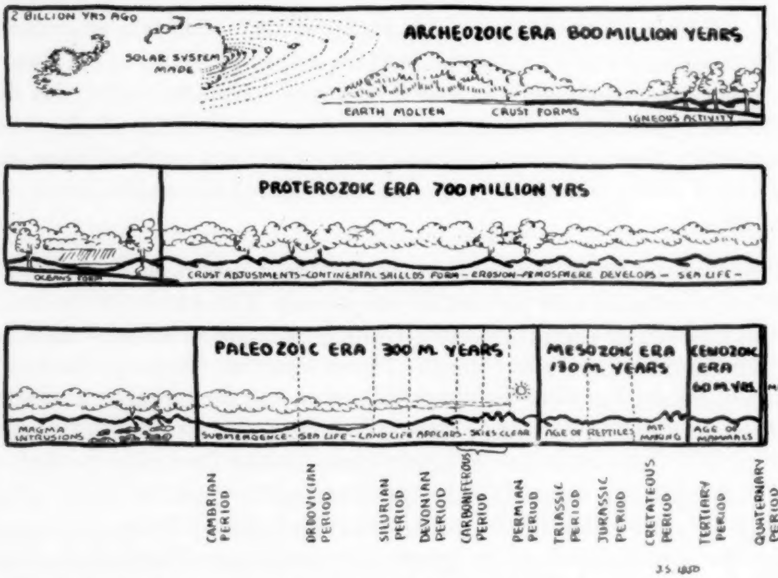
This is still the *Paleozoic Era*, during the Cambrian, Ordovician, Silurian, Devonian and Carboniferous periods. The waters of the earth had pretty much been deposited, though geologic processes changed the land and water arrangements as time went on. However the basic continental shields were well established so the terms earth and seas as used in Genesis can have literal meaning. As for plants, science has its first clear evidence of land plants in the Devonian period of the Paleozoic era. Genesis may be referring to these in verse 11 or it may be more broadly interpreted to refer back to the earliest days when the first food making, green chlorophyl containing forms appeared in the warm seas. The terms "seed," "fruit," "trees" and so on must be taken as descriptive rather than botanically accurate.

Science has evidence of some marine vertebrates in this era, but animals are not mentioned by the visionary, either because they were not visible to him or because later mention was more emphatic as will be seen. In any case scientists agree that the green food making forms of life had to be present before any animal forms, which are food using, could exist. The selective mention in Genesis of the "green herb" at this point may well be an emphasis for this fact.

And God said: "Let there be lights made in the firmament of heaven to divide the day and the night and let them be for signs and for seasons and for days and years." . . . And God made two great lights: a greater light to rule the day and a lesser light to rule the night: and the stars. . . . And the evening and the morning were the fourth day.

We are now in the Permian period of the Paleozoic era. Scientists tell of vast deserts and glaciers upon the earth at this time. In such places then, the previously misty, cloudy, tropical climate had given way to clear skies in which the sun, moon and stars could show for the first time in the history of the earth. These are therefore mentioned for the first time at this stage. In any event these verses cannot be taken literally to mean creation of the luminaries but rather their first appearance. Interpreted in this way they fit well with the known facts of the earth's development.

GEOLOGICAL TIME SCALE



And God also said: "Let the waters bring forth the creeping creatures having life and let flying things fly over the earth under the firmament of heaven." And God created the great water monsters and every living moving creature which the waters brought forth. . . . And He blessed them saying: "Increase and multiply and fill the waters of the sea and let the flying things be multiplied upon the earth." And the evening and the morning were the fifth day.

The *Mesozoic Era* is now described. It is the age of reptiles. Huge dinosaurs roamed the sea borders and the swamplands. The seas were full of "saurian" monsters, and in the air the pterodactyls and archeopteryx aptly fit the description given for the fifth "day." Animals of this age depended on water for their existence, hence the accurate stress on this phase. These verses are scientifically accurate as well as poetically descriptive.

They may also be interpreted more broadly as referring to the whole sequence of animal creation back to late Archeozioc times. As such they accurately portray the start of all life in the waters with animal, food using, forms coming after the green, food making forms. Geology has considerable evidence of the sequence of this life from marine invertebrates to vertebrates on up to amphibian and then reptilian forms in the Mesozoic era.

And God said: "Let the earth bring forth the living creature in its kind, cattle and creeping things and beasts of the earth according to their kinds. And it was so done. . . . And God said: "Let us make man to our own image and likeness and let him have dominion over the fishes of the sea, and the fowls of the air, and the beasts, and the whole earth and every creeping creature that moveth upon the earth." . . . And God saw all the things that He had made and they were very good. And the Evening and morning were the sixth day.

We are now in the *Cenozoic Era*, the era of recent life. This is the age of mammals and of man. The records of science and Genesis agree nicely, for in both, mammals and man appear last upon the scene.

So we see that the account of creation as given in Genesis is not in any essential way in disagreement with the records of science. We read of the original void, the appearance of light, the formation of earth, sea, and atmosphere. Then comes the green forms of life, followed by a lifting of the clouds to reveal the sun, moon, and stars. Next come the animals, first in the waters and then on the land. And finally man appears, last in the long line of creation.

It would be well to conclude this article with some general principles which must be kept in mind in matters of this kind.

First of all we need to recognize that the Bible is not, and was not meant to be, a book of science. It is primarily a book about God and man's relations with Him and his fellowman.

Next we must remember that the Bible was written for simple, non-scientific folk of a long past time. Hence its style is descriptive rather than literal and couched in terms that were meaningful to the people for whom it was written, though not necessarily for people of today. We cannot hope to understand all its meanings except as it is seen against a study of the age for which it was written. Most, if not all, Bible difficulties arise from a failure to understand the modes of expression which were current when it was written. This becomes more obvious if we consider how distorted, or even meaningless, some of our American expressions are when literally tranlated into another language. Multiply this by the numerous translations of

the Bible over thousands of years and it becomes a wonder that the Bible is not harder to understand than it is.

Let us further remember that the sequence of events in the Bible is often logical or psychological rather than chronological. This is not a unique device, for writers have always used it to point up points of emphasis. The Bible was not meant to be a textbook, neatly arranged with facts and events in precise sequence. What is in the Bible is true enough, but not all that is true is in the Bible, nor necessarily in "proper" order.

Still another basic principle, already mentioned earlier, is that Truth can never conflict with itself. Hence the Bible and science cannot possibly be in conflict, though the complexity of Bible interpretation may sometimes make it seem so, especially to the layman. It is quite clear that if a literal interpretation of some Bible passage violates proven scientific or historical fact we must treat the passage figuratively and seek its meaning in that direction. This in no way means the bible is wrong, but only that it is not simple to interpret.

Specifically as regards the story of creation we must consider certain important points:

1. The "days" obviously are not periods of 24 hours. They refer to a sequence of events which span two billion years.
2. There is a possibility that the vision was revealed to the writer of Genesis in six or seven episodes, or even over a period of six or seven days and was then recorded in such order.
3. While the present sequence agrees quite well with the main outlines of geological history it is possible that some of the "difficult" passages are in the logical, rather than chronological order as mentioned earlier. It may even be that the order of succession may have been altered in past translations for special purposes.

The most important thing, so far as this writer is concerned, is that the account given in Genesis, when seen as here described, is in really quite remarkable agreement with the best ideas that science has on the subject. The writer has had his faith in both religion and science strengthened by the study. If even a few readers are prompted to undertake similar investigations this effort will have been amply rewarded.

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HOW TO MAKE AN EYE LOOK LIKE AN EYE

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All the eyes we ever see, look like Fig. 1. All the models of eyes look like Fig.2.

Fig 1.

Fig. 2

Fig. 3

Models are helpful even in the younger grades in teaching health and science, but they are often confusing to children.

Suppose we try to make a model eye look like a real eye to children. Use a large piece of oak tag. On it draw the shape of a face to the same scale as the model. Then cut out the face. Draw in one eye and cut out the space where the other would be. See Fig. 3.

If the model eye has a blue iris, color the oak tag eye about the same color.

The oak tag face may then be held up in front of the model eye. One of the easiest ways is to set the model eye near the edge of a table and then hold the oak tag face in front of it.

The children can then see that part of the eye is inside the head

and that only the colored part and a little of the white is ordinarily seen.

The model eye may be moved to make the oak tag face look as if it were looking out of the corner of one eye. This will show the children that the whole eye turns, not just the colored part, as probably many have always imagined.

The oak tag face will remove much of the confusion from models that don't look like the real thing.

It works with a model ear too, using an oak tag face profile. Try it next time you bring a model to class and a child says, "Hey ,what's that thing?"

MAGNETIC FIELD OF A CURRENT-BEARING CONDUCTOR; ELECTROLYTIC CONDUCTION

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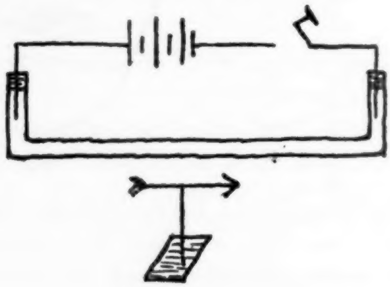
Take a 50 cm. length of glass tubing, inside bore roughtly 2 cm., and bend its ends at right angles to its length, the bent-up ends being 3 or 4 cm. long. Fit the ends with rubber stoppers and metal electrodes. Platinum is preferable. Support the tube horizontally and fill it with a strong electrolyte (a solution of sulphuric acid of specific gravity 1.4 is good). Connect the terminals to a 6 volt storage battery through a key.

Now align the tube in the N-S magnetic meridian and place a pivoted compass needle under the tube in this same alignment. Close the key. Electric conduction is evidenced by the deflection of the needle.

An appropriate discussion may now center around conductivity of electrolytes, ion migration, magnetic fields around current-bearing conductors, Oersted's observations, Ampere's rule of thumb, etc.



THE NEA SPEAKS ABOUT PUBLIC FUNDS

The Association believes the American tradition of separation of church and state should be vigorously and zealously safeguarded. The Association respects the rights of groups, including religious denominations, to maintain their own schools so long as such schools meet the educational, health, and safety standards defined by the states in which they are located.

The Association believes that these schools should be financed entirely by their supporters. The Association therefore opposes all efforts to devote public funds to either the direct or the indirect support of these schools.

CUTTING STARS AND REGULAR POLYGONS FOR DECORATIONS

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College Mathematics Editor, D. C. Heath and Company, Boston, Massachusetts

Teachers and pupils in this vicinity have been interested in these short-cut methods of cutting stars and regular polygons. Perhaps you would like to try them too. Each figure is made with just one cut of the scissors after the paper is properly folded. If thin paper is used and the folds are made with care, it is easy to cut stars having from 3 to 10 points and corresponding regular polygons that will be sufficiently accurate for decorative purposes. The thin-paper figures can then be pasted on cardboard or they may be used as patterns for making figures out of more substantial material. For practice in making the folds, it is suggested that $8\frac{1}{2}\times 11$ onionskin paper be used.

For a 3-pointed star, see Fig. 1(a) and Fig. 1(b). 1. Fold a piece of $8\frac{1}{2}\times 11$ onionskin paper so that the shorter sides are together. Crease the fold. This crease is shown as line AB in Fig. 1(a). 2. Take a point O on AB and fold OB to position OB' so that $\angle AOB' = \angle B'OE$; crease OE. 3. Crease on OB' in Fig. 1(a), folding OA over to fall as OA' along OE in Fig. 1(b). 4. Cut on line XY, making $\angle XYO$ greater than a right angle. The triangle OXY will unfold as a 3-pointed star. (Cuts on XW and XZ will be mentioned later in this article.)

In step 3, if OA does not fall exactly on OE, $\angle AOB'$ was not made equal to $\angle B'OE$ in step 2, and it is necessary to go back and adjust that fold.

In the figures in this article, the point O is the mid-point of AB, but actually it is not necessary to take O exactly at the mid-point.

For a 5-pointed star, see Fig. 2(a), Fig 2(b), and Fig. 2(c). 1. Crease on line AB as for the 3-pointed star. 2. Fold OB to position OB' so that $\angle AOB' = \frac{1}{2}\angle B'OE$ in Fig. 2(a); crease OE. 3. Fold OE to position OE' along OB' in Fig. 2(b); crease OF. (Check: $\angle E'OF$ should equal $\angle AOE'$.) 4. Crease on OE', folding OA over to fall as OA' along OF in Fig. 2(c). 5. Cut on XY to make a 5-pointed star.

For a 4-pointed star, see Fig. 3. 1. Crease on line AB as before. 2. Fold OA over to fall as OA' on OB and crease OE; this makes $\angle BOE$ a right angle, as in Fig. 3. 3. Fold OA' and OB over to fall as OA'' along OE and crease OF. 4. Cut on XY to make a 4-pointed star.

For an 8-pointed star. 1. Fold as in steps 1–3 for the 4-pointed star. 2. Fold OF in Fig. 3, over to fall on OE and crease. 3. Cut off an obtuse triangle to make an 8-pointed star.

For a 6-pointed star. This can be made by folding as for the 3-

pointed star and then folding again as in making the 8-pointed star from the pattern for the 4-pointed star. However, the method shown

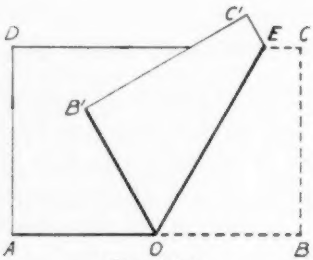

Fig. 1(a)

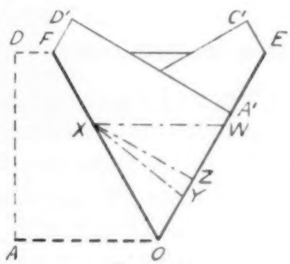

Fig. 1(b)

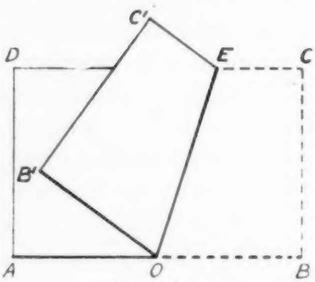

Fig. 2(a)

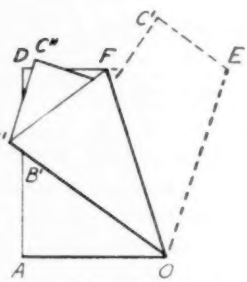

Fig. 2(b)

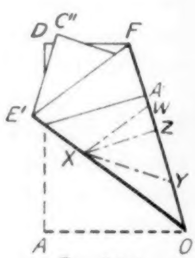

Fig. 2(c)

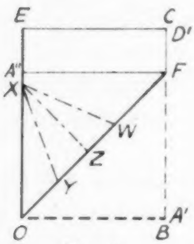

Fig. 3

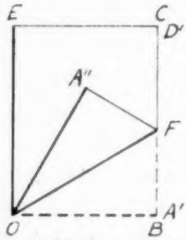

Fig. 4

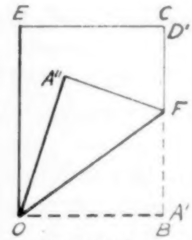

Fig. 5(a)

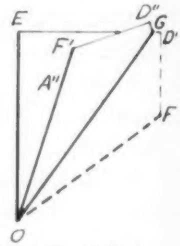

Fig 5(b)

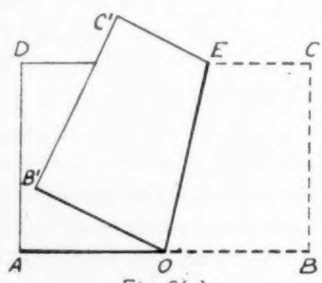

Fig. 6(a)

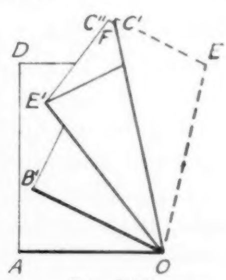

Fig. 6(b)

in Fig. 4 usually gives better results. 1. Crease on line AB. 2. Fold OA over to fall as OA' on OB and crease OE. 3. Fold OA' and OB to posi-

tion OA'' in Fig. 4 so that $\angle EOA'' = \angle A''OF$; crease OF. 4. Crease on OA'', folding OF over to fall along OE. 5. Cut off an obtuse triangle to make a 6-pointed star.

For a 10-pointed star. This can be made by making an additional fold after folding as for the 5-pointed star, or the method shown in Fig. 5(a) and Fig 5(b) may be used. 1. Crease on line AB. 2. Fold OA over to fall as OA' on OB and crease OE. 3. Fold OA' and OB to position OA'' in Fig. 5(a) so that $\angle EOA'' = \frac{1}{2}\angle A''OF$; crease OF. 4. Fold OF over to fall as OF' along OA''; crease OG. (Check: $\angle F'OG$ should equal $\angle EOF'$.) 5. Crease on OF', folding OG over to fall along OE. 6. Cut off an obtuse triangle to make a 10-pointed star.

Notice that the folds for the 6-pointed star shown in Fig. 4 follow the same pattern as those for the 3-pointed star but are applied to the right angle EOB instead of to the straight angle AOB. Similarly, the folds for the 10-pointed star shown in Fig. 5(a) and Fig. 5(b) follow the pattern of the folds for the 5-pointed star but are applied to a right angle instead of to a straight angle.

For a 9-pointed star. 1. Fold as for the 3-pointed star, Fig. 1(b). 2. Apply the pattern of folds in steps 2–3 for the 3-pointed star to the 60° angle FOE. 3. Cut off an obtuse triangle to make a 9-pointed star.

For a 7-pointed star, see Fig. 6(a) and Fig. 6(b). 1. Crease on line AB. 2. Fold OB to position OB' so that $\angle AOB' = \frac{1}{3}\angle B'OE$ in Fig. 6(a); crease OE. 3. Fold OE to position OE' so that $\angle B'OE = \angle E'OF$ in Fig. 6(b); crease OF. 4. Crease on OE', folding OF over to fall along OB'. 5. Crease on OB', folding OA over to fall along the crease on OE'. 6. Cut off an obtuse triangle to make a 7-pointed star.

If some points of the stars are imperfect, the trouble may be that one of the inside folds was doubled over in making a later fold or that the cut XY was made so far from point O that not all the layers of paper were cut at the outer end of XY.

The regular polygons are made by folding paper as for the stars and then cutting off right or isosceles triangles instead of obtuse triangles.

For an equilateral triangle. Fold as for the 3-pointed star in Fig. 1(a) and Fig. 1(b), and cut on XZ in Fig. 1(b) perpendicular to OE, cutting off right triangle OXZ. (Or the cut may be made perpendicular to OF.)

For a square. Fold as for the 4-pointed star in Fig. 3 and cut off right triangle OXZ.

For a regular pentagon. Fold as for the 5-pointed star and cut off right triangle OXZ in Fig. 2(c).

For a regular hexagon. Fold as for the 3-pointed star and cut on XW in Fig. 1(b) so that triangle OXW is isosceles. Or fold as for the 6-pointed star and cut off a right triangle.

For a regular heptagon. Fold as for the 7-pointed star and cut off a right triangle.

For a regular octagon. Fold as for the 4-pointed star and cut off isosceles triangle *OXW* in Fig. 3, or fold as for the 8-pointed star and cut off a right triangle.

For a regular nonagon. Fold as for the 9-pointed star and cut off a right triangle.

For a regular decagon. Fold as for the 5-pointed star and cut off isosceles triangle *OXW* in Fig. 2(c), or fold as for the 10-pointed star and cut off a right triangle.

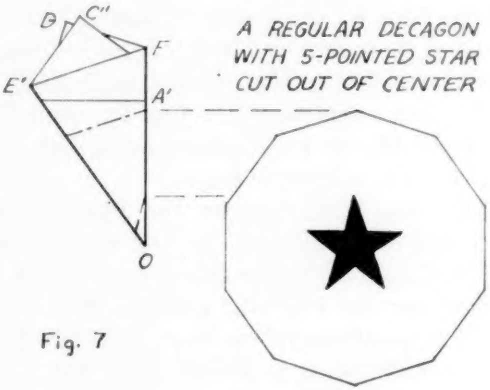

Fig. 7

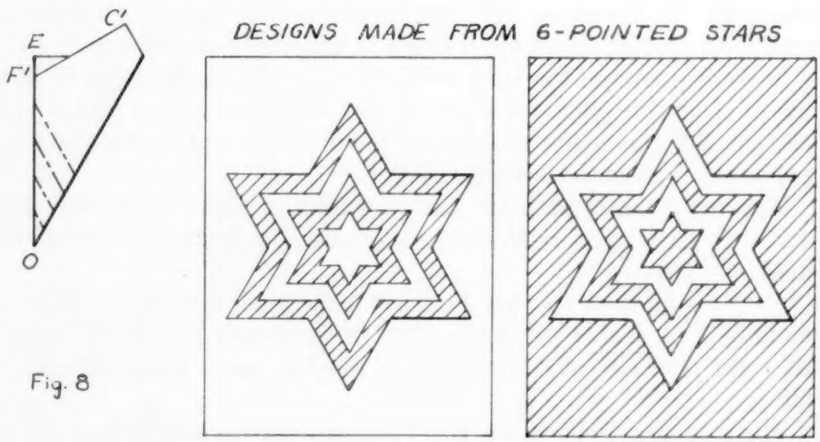

Fig. 8

For a regular polygon of 12, 14, 16, 18, or 20 sides. Fold as for a star of 6, 7, 8, 9, or 10 points and cut off an isosceles triangle.

Variations. A number of decorative figures can be made by combining the cuts described above. For instance, after a cut has been made for a large star, a short cut can be made close to *O*, either par-

allel to the first cut or from the opposite fold. This will give a large star with a small star-shaped hole in the center.

Similarly, a small star can be cut out of the center of a regular polygon. A regular decagon with a 5-pointed star cut out of the center is shown in Fig. 7.

In Fig. 8, designs made from 6-pointed stars are shown. The paper is folded as for a 6-pointed star and then four parallel, equally spaced cuts are made as shown. The five pieces may be unfolded and pasted on colored paper to give the two designs.

ISOTOPES IN THE GENERAL CHEMISTRY COURSE

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There are many topics in general chemistry which need no more emphasis today than they have had in the past. For instance, although technological advances in the manufacture and use of steel are constantly in progress, the fundamental chemistry of the blast furnace has remained essentially the same for years. On the other hand, there are some subjects which have grown in prominence very rapidly because of recent discoveries in fundamental science. The existence of isotopes is such a subject, and its treatment in the general chemistry course should reflect its importance.

For about twenty-five years isotopes have been included in freshman chemistry as the necessary explanation of fractional atomic weights. At present isotopes need no more emphasis from this standpoint than they did previously. But we are now living in the age of atomic energy, which owes its beginning to the relatively recent discovery of fission. This era may just as well be called the age of isotopes. The key point in understanding uranium fission is not concerned with the existence of uranium atoms, but rather with the fact that there are uranium atoms of different weight. It is the isotope of mass number of 235 which is fissionable; moreover, its rareness is one of the factors which must be considered in realizing the marvelous accomplishment of atomic energy. More recently the hydrogen bomb has been the center of scientific and military attention on an international scale. It would be more appropriate to call this the "deuterium-tritium" or hydrogen isotope bomb, for the principles of thermonuclear fusion in this new instrument of destruction will make use of the heavier isotopes of hydrogen as the most promising components. One must know something of the nature of these heavy hydrogen

atoms before he can make even a start towards acuqiring a fundamental understanding of this new weapon. Examples of peaceful applications which are leading to vast social changes could be cited which would point out the need for more stress on isotopes than is customarily accorded them in the general chemistry course.

Unfortunately, needed emphasis on isotopes cannot be had by following the treatment in many of the widely used freshman texts. Although the subject is introduced early, together with a few examples, it is usually promptly forgotten, or submerged in the more sensational features of atomic energy and radioactivity. A more continuous plan of presentation is desirable. One means of accomplishing this is by including a discussion of the isotopes of various elements under their description throughout the whole course. It is not inferred that mention of natural and radioactive isotopes of every element studied is necessary or desirable. This would occupy too much time and would add more factual material to a course already overburdened in that respect.

A reasonable practice is to select for isotopic discussion one element from the periodic groups as they appear in the schedule of the course. All three hydrogen isotopes, because of their general usefulness in pure and applied science, should be made familiar to the students near the beginning of the course. Their names, nuclear structure, and stability should be stressed. Thereafter, the isotopes of one element in each group can be given some consideration. Following are some briefly stated suggestions taken at random. Fluorine consists of atoms all of which have the same weight; about one-quarter of the elements are similarly homogeneous in their isotopic content. Radiocarbon (C^{14}) is produced from nitrogen atoms by neutron bombardment of calcium nitrate or beryllium nitride in the atomic pile of the Atomic Energy Commission at Oak Ridge, Tennessee. Radiosodium (Na^{24}) can be made by bombarding sodium chloride with deuterons. The eight isotopes of cadmium can be listed to show an example of an element with a complex isotopic composition. Neon can be given its historical recognition by pointing out that it was the first non-radioactive element which was found to consist of isotopes. Radiocobalt (Co^{60}) shows promise of becoming a substitute for radium. In addition to such repeated and spreaded mention of isotopism as a phenomenon found throughout the whole periodic system, an advanced lecture or two can be given near the end of the year. Some of the aspects of isotopes treated earlier can be reviewed and amplified; or more difficult topics, such as the separation of stable isotopes, exchange reactions, and even some of the amazing phenomena of "hot atom" chemistry, may be explained in a simplified manner.

What is the aim of this emphasis? Should freshmen be expected to assimilate everything or almost everything that might be said in this program of stressing isotopes? The answer to the latter question is definitely negative. It must be realized that practically anything which can reasonably be given to freshmen must necessarily be only introductory. One cannot hope to cover isotopes intensively or extensively in the general course. Rather, the aim should be to alert beginning students to the fact that science has advanced very rapidly in the last decade, and therefore today there are many important phenomena which find their explanation only in the recognition of the existence of isotopes. Students should be made to realize that the day is past when they can at all times regard atoms of every element as homogeneous in weight and chemical properties. Unless we make our students conscious of isotopes, they will be scarcely any better prepared than the average layman in understanding the various aspects of atomic energy which daily find their way into the newspapers. Moreover, teachers of freshmen must never forget their obligation to instructors in higher courses to provide students well grounded in fundamentals. The teacher of atomic physics or spectroscopy will not expect a student's mind to be a catalogue of isotopic information about even one element. But such a teacher, in explaining spectroscopic isotope effects, should not have to explain the definition and significance of the term, isotope. The teacher of biochemistry will not expect his students to be familiar with all of the principles of tracer methodology; yet he should not have to spend his time explaining what a radioactive isotope is. But the meager treatment afforded isotopes in many general chemistry texts is not sufficient to make a lasting impression, so that such difficulties in advanced courses are too common.

In conclusion, it may be said that, although phenomena involving the existence of isotopes are not numerous (considering nature as a whole), nevertheless the emphasis here advocated must be made, because these phenomena are of the utmost importance both to the world at large and to the world of pure and applied science.

INDIANA CONFERENCE ON TEACHER EDUCATION

More than 500 educators from the 48 states and all U.S. territories participated in the 1950 National Conference on Teacher Education and Professional Standards held at Indiana University, June 27–30, under the sponsorship of the NEA Commission on Teacher Education and Professional Standards. The conference was devoted to a study of problems concerning standards for institutions that prepare teachers.

SOME CONTRIBUTIONS OF THE BELL LABORATORIES IN THE DEVELOPMENT OF COMMUNICATIONS*

EMMETT C. BELZER
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Man has always been interested in getting an idea from one place to another with a minimum of delay. The story of Pheidippides, who ran over 26 miles to report the outcome of the Battle of Marathon, is a classic example. Other simple ways of communicating over a distance have included the use of carrier pigeons, reputedly introduced by the Chinese, the "jungle telegraph" of African signal drums, and the American Indian's smoke signals.

From these simple devices to our present telephones, teletypewriters, radio and television, is quite a jump. It has come about through that ideal blend of curiosity and determination which makes up the spirit of research.

Until recent years, most of the significant discoveries contributing to mankind's scientific knowledge were made by individuals. Thus, on March 10, 1876, Alexander Graham Bell, working with a single assistant, Thomas A. Watson, succeeded in transmitting the first complete sentence by telephone over a circuit some fifty feet long. It was conclusive proof that Bell was correct in his belief: such communication should be possible "if a current of electricity could be made to vary in intensity as the spoken word makes the atmosphere vary in density."

By contrast, most current technological progress in communications is accomplished through teamwork and the utilization of knowledge gathered painstakingly by many research scientists. As an example, the transistor, a simple, tiny amplifier which can fulfill most of the functions of a vacuum tube and probably some others, was recently developed in the Bell Telephone Laboratories by a three-man team: Drs. William Shockley, John Bardeen and Walter H. Brattain.

Of the six thousand-odd people who compose the Bell Telephone Laboratories staff, over a third are electrical or mechanical engineers, chemists, metallurgists, physicists and astronomers. Their pooled efforts are devoted to the solution of communications problems.

One of the first difficulties encountered in transmitting speech by wire was that of maintaining volume over long distances. As it

* A digest of the text of a lecture-demonstration by Emmett C. Belzer, Indiana Bell Telephone Company, at a science symposium for grade and high school teachers—Butler University—July 26, 1950.

traveled along the wire, the electrical current carrying the message was gradually dissipated; the smaller the wire, the sooner it died out. Larger wire was tried. It helped, but became prohibitively expensive as more and more miles of circuits came into use. Shouting would be effective up to a point; it was, however, totally inadequate on a transcontinental call.

Bell Laboratories men cleared that hurdle first by the use of loading coils and later with the vacuum tube amplifier, or repeater, which in effect takes the faint dying whisper of your speech and turns it into a mighty shout that carries as far as the next amplifier. On a typical New York to San Francisco call it takes about 180 repeaters, spaced every 16 miles, to boost your voice along.

With telephone wires strung on poles, as they always were at first, there was soon a veritable forest of poles, crossarms and wires in any thickly populated area. The amount of space occupied and maintenance difficulties made the situation undesirable. After it was found that paper insulation wrapped around a wire would serve just as well as air space to keep it electrically separated from the others, it became possible to group the wires together, placing them in a lead pipe for convenience. Nowadays, we call this arrangement a cable. Use of repeaters made it possible for the wires to be very small, so that over 4,000 of them can be contained in cable only a little over two and one-half inches in diameter.

About twenty years ago (May 23, 1929), two Bell Laboratories engineers made another far-reaching contribution to the development of cable. Lloyd Espenschied and Herman A. Affel invented the coaxial cable, the first installation of which was at Phoenixville, Pa., late in 1929. The name coaxial comes from the fact that a copper pipe about the size of a lead pencil, used as a tube, and a copper wire centered within it, have the same axis. The wire, approximately as thick as the lead in a pencil, is held in exact position by insulating disks about an inch apart. The tubes are used in pairs, each transmitting in one direction.

Each coaxial pair can carry, by a wide frequency of electrical waves which are confined within the tubes, as many as 600 telephone conversations, or two television programs, simultaneously—most present-day installations of cable contain eight tubes. Recent advances at the Laboratories are expected at least to double, possibly to triple this capacity. By the end of this year, around 12,000 miles of such heavy-duty communication pipe-lines will interconnect the large cities of the East, Middle West and the Pacific Coast. Most coaxial cable is buried, to be out of the weather, and filled with nitrogen gas under pressure to give an automatic alarm in case of damage.

Most recent of the telephone pathways developed is the radio-

relay system. Depending upon a small focussed beam of very short radio waves which follow a line of sight path from one station to another, this method has the advantage of being free from the necessity of continuous wire or cable. The structures used are constructed of steel or concrete; they vary in height, depending upon the terrain, and carry at the top cone-shaped antenna "lenses" to receive and send on the focussed radio beams. So accurately can the aiming be done that it is routine to hit squarely the 10-foot square receiving antenna on a station 30 miles away.

Your conversation, traveling along in a coaxial cable or on a radio relay beam, is only one of several hundred, Each conversation, however, has its own band of frequencies or wave lengths, just as each station you get on your radio has its allotted place among all the broadcast frequencies.

Separation of the messages without confusion might seem to be difficult. It would indeed be, were it not for a peculiarity of certain minerals, such as quartz. Laboratories technicians discovered some time ago that the property of a quartz crystal which will let through a certain band of frequencies while screening out others made these crystals ideal for use in filters. Utilizing this principle, they devised crystal filters, each of which will let through only the one conversation to which it is tuned.

Going a step further, the Bell scientists have actually improved on Nature by "growing" synthetic crystals in the Laboratories. Starting with a small "seed" the process involves agitation at constant temperature in a saturated solution of ethylene diamine tartrate; when the "growth" is completed (in a few months instead of the many years it takes to produce natural Brazilian quartz) the crystals are removed and sliced to specification. A small section of the new artificial (EDT) crystal will, like quartz, vibrate with unvarying frequency when electric current is applied to it. Its filtering action in separating out a given telephone conversation is similar to that which takes place in a radio set when a listener turns his dial to select a particular station.

These are but a few of the activities pursued in the Bell Telephone Laboratories in the pursuit of answers to communications problems. The search goes on, with the admonition of Dr. Bell constantly being followed: "Don't keep forever on the public road, going only where others have gone. Leave the beaten track occasionally, and dive into the woods. You will be certain to find something you have never seen before. Of course, it may be a little thing, but do not ignore it. Follow it up, explore all around it: one discovery will lead to another, and before you know it you will have something really worthwile to occupy your mind. All really big discoveries are the result of thought."

APPLYING THE SENSES

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Science—the Pivot

"It is the atomic age." . . . "We live in the scientific technological era." . . . "In our lifetime, science will see that we take our trip to the moon." . . .

We hear these remarks and many similar statements made every day. This theme pervades advertising, industry, politics and individual lives. Granted, this is a scientific era upon which nearly every human activity is pivoting. Therefore, we teachers must guide our thinking and planning accordingly if we are to make learning meaningful, functional and effective for our youth. If the aim of teaching science is to be that of bettering human relationships and the lot of all people, then science courses must be as practical, as meaningful, and as applicable as possible.

Science, upon which technological advances depend, is a study of concepts and the application of these to improve upon ways and means of daily activities. The food supply, as well as the very shoes on our feet, is dependent upon the applications of scientific principles. The standard of living in our "way of life" is hinged upon the ability of people to apply themselves to the problems at hand.

Remember the time when science was difficult and its study was left for the professors and scholars to understand? Surely, there is no doubt in anyone's mind today, concerning the role of science in the lives of all individuals. As it is taught in many schools today science is made simple by being linked with common objects and situations in the immediate environment. Elementary and junior high aged children are seeing new meanings in science classes as they become inquisitive about the things they get for Christmas or can purchase in the store and most of all, from the things they make themselves.

Reading "About" Science is Lifeless Rehashing

Reading "about" science is dead and lifeless unless the reader has already experienced similar situations. The telescope cannot mean much more than a word on paper unless a person has actually seen one or looked at distant objects with one.

Teachers should not demand a mass of predigested, warmed-over material from these students. Such a technique siphons off the child's natural zest for inquiry and discovery. Teachers "must be concerned about the child's ideas of himself and of the world. It is in this direction that *science* plays a large part. Teaching content item by item

without concern about what is happening to the child's own orientation to his world will not serve the goals of science education."[1]

Solitary concern with facts excludes development of desirable behavior stemming from healthful attitudes and understanding.

Dr. Gerald S. Craig, when speaking to the National Council on Elementary Science meeting in Denver, February 11, 1950, emphasized that many of the early fundamentals of science meanings are "largely sensory and nonverbal in character. They may include such experiences as roughness, smoothness, sharpness, lightness, heaviness, friction, gravity, momentum, inertia and many others. We need to give a more recognition to the stage of learning about the environment which is experiential and sensory in character."

The writer's purpose is to show how the classroom can capitalize on the sensory side of learning.

Learning Through Doing

Teachers should provide experiences that involve muscle activity to satisfy the need for muscle activity in rapidly growing youngsters. Overt "doing" is as essential as any other element in a child's learning. To neglect this leads to confusion of symbols and terms, inaccurate thinking, misconceptions and fuzzy learning.

Let students solve problems by working them out through model building, research, animal fairs, or demonstrations of concepts. Help the child find out through experimentation with mice what the effects of alcohol can be on his body. Urge and direct the child to make models and diagrams. When studying astonomy or light, the subject of telescopes usually stimulates some child. When that person becomes vitally interested, it would be unwise to read, to the exclusion of other activities, more about the telescope. Reading about it becomes secondary to the real thing if he is urged to make his own model.

The volcano's inner structure is better understood when the student makes his plaster of Paris model than when he reads about it in a book. The two, experience and reading, develop a lasting concept for him.

One group of seventh grade youngsters, after seeing the movie "In Our Ponds," developed an interest in animal life in the nearby park. When a field excursion was used as a follow-up activity, several boys searched until they found a "blood sucker." The leech was brought into the classroom for observation for several days. Others were curious about the jell-like deposits on the side of a submerged tin can. What are those? Are they animals? Are they snail eggs incu-

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[1] Craig, Gerald S., "Unfinished Business in Elementary Science," *Teachers College Record*, vol. 50, (March, 1949), pp. 410–416.

bating? Both were observed by using the hand lens. The teacher pointed out the similarity of the eggs on the tin can and those on the sides of the aquarium.

The little boys learned by these experiences to see relationships, and to be aware of very small things they usually by-passed.

Making of diagrams is another way for a child to express himself in science. When studying air, seventh grade twins were impressed with the force wind has. It must have force to push a sail ship, mustn't it? They did their reading to find out more details. They already had an interest in sail ships and had built their own models. To show how the force of moving air is applied, the twins drew a diagram, calling it, "Wind at Work." The ships were featured on the water and in diagrammatical fashion, the wind was shown, by arrows, to be filling up the sails and pushing the ship.

The sense of feeling is one so many times neglected when teaching science. Yet everyone knows how a very small baby feels the textures of everything he can. Touching with the hands is not enough for the baby. He tries everything with his little tongue, too. In the classroom this sense of the nervous system can be used when teaching textures of rocks and soils. For instance, " . . . a grainy, rough, pebble conglomerate" is meaningless talk when used without showing and handling such a specimen and comparing it with other materials in their environment.

Molecular theory becomes more understandable whenever it is linked with solid desks, and flowing water, and gaseous odors. Whenever the teacher needs to develop the concept of molecules in organization, diagrams are drawn on the blackboard. Then water is poured into various shaped containers to show fluidity, and a bottle of household ammonia is uncorked in the room. Unvariably there is someone who says, "What's that I smell?" Then again the diagrammatic explanation of molecular action of gases is presented so the child can better understand what is happening.

The sense of taste is employed in teaching when teaching the process of purification through distillation. Apple cider which has soured into vinegar is used as the liquid for distillation. Is it really vinegar is answered not by telling but by tasting.

Needless to say, the others of the senses—sight and hearing—are never left out in the usual science room. They come in handy when collecting oxygen as a demonstration. The "bark" test, as called by the children, when applied to a small quantity of oxygen collected in a test tube, is one of the thrills these students enjoy. Other uses of the sense of sight and hearing are obvious.

All the foregoing examples may not be challenging to every child in the class. To all the sense of sight is the strongest aid to learning,

but some things that are heard are the individual's modality of learning. However, variety in teaching and presentation appeals to a greater range of interests than do the "reading about" science activities so often used in the conventional class-room. Learning can be interesting and therefore bring about the desire to go to classes.

Direction for Adjustment

One aim of science education is that of "helping people find better ways of solving problems." Here again methods of teaching this are aided by various applications of the senses. Modality of learning for individuals varies with each person. Variety, when teaching problem solving, gives a foundation of experiences for all participating individuals to reorganize into their thinking pattern when confronted with a similar situation at a later time. There has been a statement made that learning involves a constant reorganization of experiences which enables the individual to adjust to new situations. Teachers of science must provide opportunity for pupils to reorganize their experiences as a basis for solving personal problems. A classroom program which creates this tie between the schoolroom experience and real-life activities becomes real and vital to the child.

It must be cautioned that teachers need to provide a continuity of experiences when developing the skill of handling problems. A hodge-podge helter-skelter, uncoordinated set of activities can result in disaster if all is not planned and organized with definite goals in mind.

Projects that Have Been Developed

Stimulation and encouragement for making projects runs high in the school in which the writer teaches. In connection with a section on geology one student made a plaster of Paris model of the cross section view of a volcano. Preliminary to its construction certain basic facts concerning the shape of the cone and the probable internal structure of a volcano had to be fixed in the child's mind. In addition, it became necessary for him to use his ingenuity to set up a form for molding the cone. He needed to know the nature of the plaster he was working with before he could begin the actual process of molding. The finished model will be a visual aid very helpful in teaching for several years.

It is to be desired that the readers of this article do not get the impression that a great emphasis is laid upon the keeping of great numbers of these student-made objects. Usually a project serves as an idea or inspiration to members of the following class more than it becomes a standard piece of equipment which is used at a precise time.

Students find it quite difficult to realize the space relationships in

the astronomical universe. Several methods for visualizing this can be used. One is to use a large cardboard upon which are drawn a series of circles to represent the relative orbits of the planets. Planets are made by covering wadded newspapers with tinfoil. Each wad of paper should be scaled approximately to the size of each planet. After the balls are covered they are placed upon the circles in their correct order from the sun and fastened down with pins.

The other suggestion is to have cork or paper mache balls scaled to coincide with the sizes of the planets fastened on stiff wires which are placed on a base. Each wire is a scaled length of the distance a planet is from the sun.

When the students ask what use the rudder of an airplane has, it becomes quite easy to demonstrate if water and pieces of tinfoil are used. A large pan of water is placed in the center of the floor where all members of the class can see. Then strips of tinfoil three inches by nine inches are cut. The end of one piece is bent at a ninety degree angle; another has an approximate sixty degree angle while the other end of the tinfoil strip is kept straight. As the strip is pulled through the water, the make-believe rudder is deflected by the force of the water and the tinfoil strip begins to turn to one side. When contrasted with the movement of a strip which is straight, the use of the rudder is easily grasped. Incidental to learning how a rudder acts, students are able to see the "eddies" in water as they are unable to see them in the air.

To the collector and appreciator of rocks of various kinds, the home-made box for keeping specimens is a possession to be prized. Using plywood purchased at a lumber yard, a girl made her own box. It is forty-four inches long, twenty-five inches wide, and six inches deep. The hinges and hasp are made of pounded brass, giving it the treasure chest look. Besides being a project of material value, many other values were gained by the maker. She learned the abilities she herself had as well as those of her family. Basic principles of construction were gained by the seventh grade girl who made it.

"Value Received"

These are only a few of the many projects developed in the writer's school. The practice of encouraging the making of these things had livened the interest in science for both pupils and teachers. The children who are handicapped by a low reading level can now feel that they are making a definite contribution to their groups. It is surprising how this feeling has taken the mischief makers' minds away from creating mischief. It is the writer's opinion that the direction of physical energies into channels constructive rather than destructive eliminates many so-called discipline problems.

The students have developed a knack of challenging themselves to make something which would illustrate a concept or be an addition to the equipment in the school.

There is great pride in the work of this nature among the students of the school. They are enjoying the feeling of knowing that something they made with their own hands is being used in classes in the following year as teaching aids and as ideas for others. This pride in work has helped several children escape the feeling that they have failed completely or that they didn't count in their group.

The child who habitually "fails" in many classes that are dependent upon reading ability can come into the science class and know that there are ways of learning or proving his abilities by doing projects involving physical and manual activity. In this way learning is individualized.

The application of abstract ideas in similar situations makes the science course meaningful and stimulating for the general education group which as a rule, do not become the specialists in the field of science. They are actually the ones that use science in daily activities.

Sensory Learning Has Its Place

In summary, the writer would emphasize that growing and developing children need muscle as well as mental activity in order to learn. Science can be taken from the abstract and placed into the practical and real situation of children's lives. This is done by the teacher's appeal to the whole child through his various senses of his nervous system. The uses of all these senses seem to appeal to the active youngster who is alert to the world around him. The scope of experiences broadens as the activity is varied. Thus the foundation experiences which can be basic to well adujsted living becomes ever broader and offers a wider opportunity for the reorganization of experiences to fit the individual for adjustment in a period of uncertainty.

ANNOTATED BIBLIOGRAPHY

Barnard, Darrell J., "They Shouldn't Be in My Class," *National Education Association Journal*, Vol. 37 (December, 1948), pp. 610–611.

This cleverly written article lends conviction to the statement that teachers can select experiences for their classes which are academic exercises rather than those leading to life adjustment.

Bruce, Freeman, and others, *Development of Learning*, Houghton Mifflin Co., New York, 1942.

Certain chapters on growth and development had information pertinent to my subject.

Craig, Gerald S., "Unfinished Business in Elementary Science," *Teachers College Record*, Vol. 50, No. 6 (March, 1949), pp. 410–416.

Dr. Craig focuses attention on the areas of science that need to be improved. Most of what he says can serve as evaluative criteria for individual schools in developing science curricula.

Miller, Dorothy, "The Place of Elementary Science in the Curriculum," SCHOOL SCIENCE AND MATHEMATICS, Vol. XLVIII (May, 1948), pp. 379–381.

Elementary science needs more time allotted to it in the curriculum since it has an influence beyond "facts discovered." Science determines facts about the environment but it also enables man to control the environment through understanding. This is an article containing criteria to determine what to teach in science.

Preston, Ralph C., "Using What We Know Now about Children in Developing Science Learnings," Childhood Education (March, 1950), pp. 297–300.

Most forthright reasons for using physical activity in teaching science are presented by Mr. Preston.

Rauch, Walter E., "Army and Navy Mock-ups," *Industrial Arts and Vocational Education*, Vol. 36 (November 1947), pp. 360–363.

The practicality of teaching through doing things is ell presented as specific ways and means of teaching with mock-ups are cited.

Sharp, L. N., "Camping and Outdoor Education," *National Education Association Journal*, Vol. 36 (May, 1947), pp. 366–367.

Though not written specifically for science, much of this thesis is applicable to "learning through doing" in science teaching.

Sterning, John, "Science and the Multi-Sensory Method," *Science Education*, Vol. 33 (February, 1949), pp. 40–43.

Multi-sensory teaching as a method is not "new." But is it being used to its greatest extent? This is an article convincing teachers that they need to capitalize more on the manifested interests of children when they bring materials to science class for examination.

Wynne, J. P., *Philosophies of Education*, pp. 302–303.

The criteria for curriculum and what to include in the curriculum were outstanding for my information.

FLICKER-LIGHT TEST MEASURES INTELLIGENCE

Intelligence may some day be measured by a flickering light instead of with the conventional paper-and-pencil mental tests.

The length of the dark periods between flashes of light necessary for you to see the light as flickering and not continuous is determined by your central nervous system and not by your eyes.

New evidence of this is reported by Dr. Wilson P. Tanner, Jr., of the University of Michigan, in the journal *Science*. He found that this "flicker frequency" is related to scores on intelligence tests. It may be possible in the future to measure ability to see light as flickering, instead of giving a paper-and-pencil test to measure intelligence, Dr. Tanner suggests.

A surprising discovery in the course of the experiment was the fact that the relation with intelligence varies with the length of the light flashes separated by the periods of darkness. It increases with increase in the length of the light flash up to 84 thousandths of a second and then decreases with further increase of the length of the light flash.

Coffee tables with tops that resemble marble are made of a plastic known as melamine formaldehyde resin which will not chip, peel, or mar from cigarette burns or alcohol. They come in round, square or rectangular shapes, and a choice of colorings.

MODELS FOR INTRODUCING SPECIAL PRODUCTS

Ethel L. Grove, Charles E. Scott, and Ewart L. Grove
Cleveland, Ohio

I. Construction

A. Materials

1. One square of $\frac{1}{4}''$ thick plywood or fiberboard, approximately 18″ square.
2. Three strips $\frac{1}{4}''$ square and same length as board above.
3. Three strips $\frac{1}{2}''$ wide, $\frac{1}{4}''$ thick or less if available, and same length as other strips.
4. Four squares similar to backboard but with side $\frac{1}{2}''$ shorter.
5. Glue or nails.
6. India ink or black paint and lacquer.

B. Steps in Construction

1. Make sure backboard is square. It may be any size convenient for class demonstration. Illustrated model is 18″ square.
2. Glue or nail the three $\frac{1}{4}''$ strips along three edges of board. (Cut off excess length from side strips.)
3. Glue or nail three $\frac{1}{2}''$ strips on the $\frac{1}{4}''$ strips flush with outside edge to form groove around three sides. (Increase strength of model by allowing side strips to extend full length and shortening bottom strip one half inch.)
4. Cut four smaller boards as shown in the four patterns above. Bevel finger-holds or attach knobs to each piece.
5. Ink or paint $\frac{1}{4}''$ border around each piece and lacquer all surfaces.
6. If desired, labels for each set of panels showing given factors and the product may be written on heavy paper or balsa wood and covered with Scotch tape extending 1″ beyond the label at each end. Thus if handled carefully, labels may be attached and removed from side and lower strips of backboard a number of times.

If the teacher does not have facilities for making a model of this type, the Industrial Arts Department is usually willing to assist the teacher or some student in the algebra class with the construction.

II. Use

A. Class Demonstration

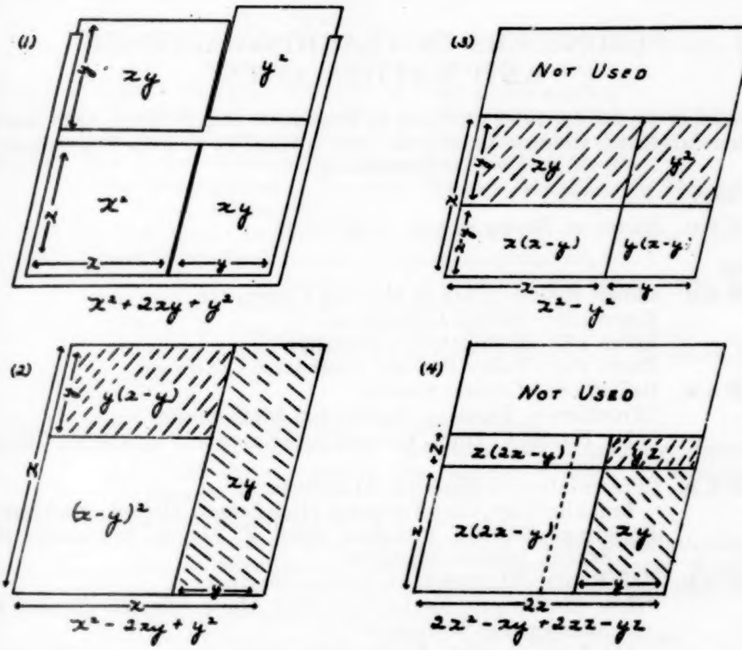
1. Use model with appropriate panels to demonstrate reasons

for each term in standard special products.

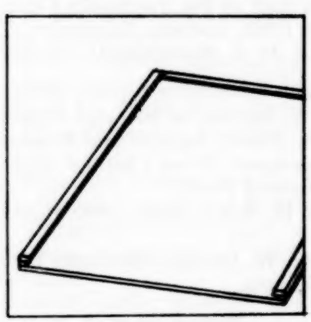
Set 1 for $(x+y)^2$ Set 3 for $(x+y)(x-y)$

Set 2 for $(x-y)^2$ Set 4 for $(2x-y)(x+z)$

Other panels may be made with numbers substituted for these letters.



MODELS FOR SPECIAL PRODUCTS



CONSTRUCTION

2. Models should be made available for pupil manipulation and study after class demonstration to fix ideas in mind.

B. Pupil Experimentation

Model may be put in convenient place before special prod-

ucts are introduced so that pupils can work with them and discover for themselves the relationships from which they can formulate special product rules. (See "Models for Introducing Parallelograms" in the October issue for complete procedure with pupil experimentation.)

"FRONTIERS IN TEACHING SCIENCE AND MATHEMATICS"

November 23, 24, 25, 1950, meetings at Edgewater Beach Hotel, 5300 North Sheridan Road, Chicago 40, Illinois. This is CASMT Golden Anniversary Convention

Thursday

7:30 P.M. American Room—Board of Directors.

Friday

8:30 A.M. Illinois Room—Place of Meeting Committee.
Room 188—Journal Committee.
Room 190—Nominating Committee.
Room 191—Policy Projects Committee Chairmen.

9:30 A.M. Ball Room—General Session:
"Frontiers in Teaching Science and Mathematics"—
Dr. Harold C. Hunt, General Superintendent of Schools, Chicago, Illinois.

10:20 A.M. "Presentation of Emeritus Memberships"—
Franklin Frey, Cass Technical High School, Detroit, Michigan.
Presiding—CASMT President Allen F. Meyer, Mackenzie High School, Detroit, Michigan.

10:40 A.M. Ball Room—Mathematics Section Meeting.
"How Movements for Improvement Have Affected Present Day Mathematics Instruction"—
Dr. E. R. Breslich, Professor Emeritus, University of Chicago.
"What Contributions to Mathematics Instruction Can We Expect in the Last Half of the Twentieth Century?"—
Mr. Philip Peak, Indiana University.
Chairman—E. H. C. Hildebrandt, Northwestern University.

Lincoln Room—Chemistry Section Meeting:
"Chemistry as Applied to Soil and Crop Production"—
Dr. Eldrow Reeve, Agricultural Research Department, Campbell Soup Company, West Chicago, Illinois.
"Synthetic Liquid Fuels"—
Dr. Frank H. Reed, State Geological Survey Division, Urbana, Illinois.
Chairman—C. W. Dewalt, Glenbard Township High School, Glenn Ellyn, Illinois.

Michigan Room—Biology Section Meeting:
"Some Practical Suggestions for the Teaching of High School Biology"—
Dr. Francis D. Curtis, University of Michigan.
"Basic Research in Science and the Student"—
Dr. James A. Reyniers, Director of the Laboratories in Bacteriology, University of Notre Dame.
Chairman—Donald B. O'Brien, Thornton Township High School, Harvey, Illinois.

Berwyn Room—Elementary Science Section Meeting:
"Five Senses—Let's Use Them"—
Participating in the program will be: Miss Louise M. Jones, Congress Park School, Brookfield, Illinois and Mr. Eric Bender, Row, Peterson & Company, Evanston, Illinois.
Chairman, Viola Henrikson, Girls Latin School, Chicago, Illinois.

1:30 P.M. Ball Room—General Session:
"Galaxies for the Classroom"—
Professor Harlow Shapley, Director, Harvard Observatories, Harvard University, Cambridge, Massachusetts.
2:25 P.M. "Report on Policy Projects of Central Association"—
Kenneth Vordenberg, Withrow High School, Cincinnati, Ohio.
Presiding—Mary A. Potter, Vice President of the Association.
2:40 P.M. Ball Room—Elementary Mathematics Section Meeting:
"The Development of Concepts Through Emphasis on Generalization in Arithmetic"—
Alice Rose Carr, Ball State Teachers College, Muncie, Indiana.
"Field Work Modifies Our Program in Arithmetic"—
E. W. Hamilton, Iowa State Teachers College, Cedar Falls, Iowa.
"Use of Paper Folding in the Upper Grades"—
Mildred B. Cole, C. M. Bardwell School, Aurora, Illinois.
Chairman, John Mayor, University of Wisconsin, Madison, Wisconsin.

North Terrace—Geography Section Meeting:
This is a joint session on Mathematical Geography, provided through the courtesy of the National Council of Geography Teachers.
"Geography Among the Sciences"—
Otis W. Freeman, Head, Department of Science and Mathematics, Eastern Washington College of Education, Cheney, Washington; Formerly, Specialist for Geography in Higher Education, Office of Education, Washington, D. C.
"Mercator Projection: Its Practical and Pedagogic Merits"—
Clarence L. Vinge, Department of Geology and Geography, Michigan State College, East Lansing, Michigan.
"The Teaching of Mathematical Concepts in Geography"—
(Speaker to be announced).
Chairman—Laura L. Watkins, Lincoln School, Cicero, Illinois.
Lincoln Room—General Science Section Meeting:
"Natural Science at the Junior High School Level"—
Sister Mary Ellen O'Hanlon, Rosary College, River Forest, Illinois.
"The Teaching of General Science from the Teacher's Standpoint"—
Dr. Francis D. Curtis, Professor of Education and of the Teaching of Science, University of Michigan, and Head of the Department of Science, University of Michigan High School, Ann Arbor, Michigan.
Chairman, Russell Shedd, Redford Union High School, Detroit, Michigan.

Michigan Room—Physics Section Meeting:
"Words Over Waves, A Demonstration Lecture"—
Mr. Roger K. Harper, Illinois Bell Telephone Company, Chicago, Illinois.
"The Development of a Course in Physical Science"—
Mr. Glenn H. Updike, Senior High School, Elkhart, Indiana.
"Physical Science and the Curriculum"—

Mr. Robert H. Carleton, Executive Secretary of the National Science Teachers Association, Washington, D. C.
Chairman, J. R. Richardson, Ohio State University, Columbus, Ohio.

4:30 P.M. Room 188—Anniversary Publication, Publicity and Promotion Committee.
Room 190—Nominating Committee.
Room 191—Policy and Resolutions Committee.
Illinois Room—Membership Committee.

6:30 P.M. Ball Room—Annual Banquet:
"Recognition of Past Achievements"—
Marie S. Wilcox, George Washington High School, Indianapolis, Indiana.
"Recognition of Present and Future Activity"—
Arthur O. Baker, Board of Education, Cleveland, Ohio.
"An Industrialist Looks at Education"—
B. D. Kunkle, Senior Vice President, General Motors Corporation, Detroit, Michigan.
Chairman in Charge—Frank B. Allen, Lyons Township High School, La Grange, Illinois.
Toastmaster—Walter G. Gingery, George Washington High School, Indianapolis, Indiana.

9:30 P.M. East Lounge—Mixer (Joint with National Council of Geography Teachers):
Chairman—Winnafred Shepard, Proviso Township High School, Maywood, Illinois.
Master of Ceremonies—Joseph P. McMenamin, Oak Park Township High School, Oak Park, Illinois.

Saturday

8:30 A.M. Ball Room—Association Business Meeting.

9:30 A.M. General Session:
"The Need of Defending the Social Foundations of Science"—
Professor Hermann Joseph Muller, Indiana University, Bloomington, Indiana.

10:15 A.M. Association Project Committee Reports:
"Teacher Research in Daily Classes"—
John R. Mayer, University of Wisconsin, Madison, Wisconsin.
"Better Evaluation Techniques"—
Helen Monroe, Northern High School, Detroit, Michigan.
Presiding—Charlotte L. Grant, Past President of the Association

10:40 A.M. Lincoln Room—Elementary School Group Meeting:
"Making Science Live for the Child"—
Sister M. Aquinas, O.S.F., Science Supervisor of Elementary Schools, Diocese of Green Bay, Wisconsin.
"The Reading Habits of Children—and How They Can Be Changed"—
Mrs. Elizabeth A. Simpson, Director, Adult Reading Service, Institute of Psychological Services, Illinois Institute of Technology, Chicago, Illinois.
Chairman—Joseph J. Urbancek, Chicago Teachers College, Chicago, Illinois.

Berwyn Room—Junior High School Group Meeting:
"Are We Using or Abusing Educational Films in Our Junior High Science Classes"—
William J. Walsh, Junior High Science, Cedar Falls Teacher's College, Cedar Falls, Iowa.

"Articulating Junior High Mathematics with Elementary Arithmetic"—
Lucille Houston, Junior High Mathematics, Burlington, Iowa.
Presiding—Willard D. Unsicker, State University of Iowa. Iowa City, Iowa.

Ball Room—Senior High School Group Meeting:
"Mathematics and Science Teaching—An Engineer's Viewpoint"—
Hans Gutekunst, Oak Park, Illinois.
"Meeting Student Needs by Integration"—
Dr. Charlotte L. Grant, Oak Park High School, Oak Park, Illinois.
Presiding: Martha Hildebrandt, Proviso Township High School, Maywood, Illinois.

Illinois Room—Junior College Group Program:
"The Mathematics Used in the Biological and Physical Science Areas in a Program of General Education on the College Level"—
Dr. Adele Leonhardy, Stephens College, Columbia, Missouri.
Presiding: Bjarne R. Ullsvik, Illinois State Normal University, Normal, Illinois.

Sheridan Room—Conservation Group Meeting (Joint with National Council of Geography Teachers):
"The History of the Great Lakes Area" (Illustrated)—
Miss Helen M. Martin, Research Geologist, Geological Survey Division, Michigan Department of Conservation, Lansing, Michigan.
"Reforestation and High School Biology" (Illustrated)—
Miss Lida Rogers, Head of Biology Department, Holland Senior High School, Holland, Michigan.
"How to Present Conservation in the Elementary Grades"—
Professor James M. Sanders, Chicago Teachers College, Chicago, Illinois.
Chairman—Edward Ray, Conservation Education consultant, Michigan Department of Conservation, Lansing, Michigan.

1:30 P.M. American Room—Board of Directors.
Berwyn Room—Section Officers.
Museum of Science and Industry—Trip.
Chairman—Meyer Halushka, Wright Junior College, Chicago, Illinois.

ESTIMATED SCHOOL ENROLLMENT FOR 1950–51

Elementary Schools	
Public	20,674,000
All other schools	3,072,000
Total Elementary	23,686,000
Secondary Schools	
Public	5,452,000
All other schools	690,000
Total Secondary	6,142,000
Higher Education	2,700,000
All other types of schools	375,000
Grand Total	32,903,000

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2191, 2193, 2194, 2195. *Oscar Marinoff, Denver, Colorado.*

2193, 2196. *William R. Ware, Canby, Oregon.*

2197. *Proposed by Francis L. Miksa, Aurora, Illinois.*

Given three spheres on a plane surface of radii 4, 5, 6 respectively, and tangent to each other. A fourth sphere of radius 3 lies on top and touching the other three. Find the height of center of 4th sphere above the plane.

Solution by Prasert Na Nagara, College of Agriculture, Thailand

Let $P(0, 0, 4)$; $P_1(x_1, 0, 5)$; $P_2(x_2, y_2, 6)$ and $P_3(x_3, y_3, z_3)$ be the centers of the spheres with radii 4, 5, 6 and 3 respectively.

Using the fact that the distance between centers, $P\,P_1=9$, $P\,P_2=10$, $P_1\,P_2=11$, one obtains:

$$x_1^2=80, \qquad x_1=4\sqrt{5} \tag{1}$$

$$x_2^2=y_2^2=96 \tag{2}$$

$$(x_2-4\sqrt{5})^2+y_2^2=121. \tag{3}$$

Solving (2) and (3), one obtains $x_2=7/\sqrt{5}$, $y_2=\sqrt{431/5}$.

Since $P\,P_3=7$, $P_1\,P_3=8$ and $P_2P_3=9$, these three equations arise:

$$x_3^2+y_3^2+(z_3-4)^2=49 \tag{4}$$

$$(x_3-4\sqrt{5})^2+y_3^2+(z_3-5)^2=64 \tag{5}$$

$$(x_3-7/\sqrt{5})^2+(y_3-\sqrt{431/5})^2+(z_3-6)^2=81. \tag{6}$$

Solving (4), (5) and (6), we obtain $x_3=10.187$.

2198. The editor confesses to absent mindedness. This problem appeared as

2196 in previous issue. Solutions were offered for this issue by: Jerome M. Glick, Brooklyn College; Marie A. Moore, St. Louis, Mo.; C. W. Trigg and the proposer.

2199. *Proposed by V. C. Bailey, Evansville, Indiana.*

If the nine-point circle of triangle ABC cuts AB in D and M, making $(AMDB) = -1$, construct the triangle when AB and acute angle C are given. M is midpoint of AB and D is foot of altitude from C.

Solution by C. W. Trigg, Los Angeles City College

If M is the midpoint of AB and A, M, D, B form a harmonic range, then $AB/(c/2-AD)=c/(c/2)$, hence $AD=c/3$. So bisect AB at M, trisect AB at D and erect perpendiculars ME and DF to AB. At B construct angle ABE equal to angle C. Draw BK perpendicular to BE at B and meeting ME at O. With O as center and radius OA describe a circle cutting DF at C. The triangle ABC thus is determined using well-known elementary constructions. The proof of the construction is obvious. We note that the nine-point circle passes through the feet of the altitudes and medians, but did not need to use it in the construction.

Solutions were also offered by Prasert Na Nagara, College of Agriculture, Thailand and the proposer.

2200. *Proposed by Norman Anning, University of Michigan.*

Solve the system of equations:

$$(q-2p)^2=(2q-p-3)^2=(p+2q-15)^2=(2p+q-24)^2.$$

Solution by Prasert Na Nagara, College of Agriculture, Thailand

$$q-2p=\pm(2p+q-24); \quad \therefore \quad p=6,\ q=12.$$

When $p=6$ is substituted in the given equations, we get $q=7$ and -3. The values $p=6$ and $q=-3$; $p=6$, $q=7$ satisfy all equations.

When $q=12$ is substituted no pair of values is found which satisfy the equations.

Solutions were also offered by: Margaret Joseph, Milwaukee, Wis.; C. W. Trigg, Los Angeles City College; Marie A. Moore, St. Louis, Mo.; Alan Wayne, Flushing, N. Y.; Bernard Katz, Brooklyn College; and the proposer.

2201. *Proposed by C. W. Trigg, Los Angeles City College.*

Only in an isosceles triangle can the line joining a vertex to the internal point of contact of an excircle with the opposite side be a symmedian.

Solution by the Proposer

Let P be the point of contact of the excircle with side a of triangle ABC. Then $BP/PC=(s-c)/(s-b)$. [N. A. Court, "College Geometry" (1925), page 75.] If AP is a symmedian then $BP/PC=c^2/b^2$. [Loc. cit., page 225.] When these two ratios are equated and the equation is simplified, noting that $2s=a+b+c$, we have

$$(b-c)[b^2+c^2+a(b+c)]=0.$$

Since the second factor cannot equal zero, $b=c$, and the triangle is isosceles.

A solution was also offered by Prasert Na Nagara, Thailand.

2202. *Proposed by Alan Wayne, Flushing, N. Y.*

In the following addition each letter represents a digit with different letters representing different digits. Restore the digits.

$$\begin{array}{r} HELP \\ THE \\ \hline YOUNG \end{array}$$

Solution by Bernard Katz, Brooklyn College

We can see by inspection that H must be 9, Y must be 1 and O must be 0. Since H must be 9, N must be one less than L, and the sum of P and E must be less than 9. Now P and E can only be either 4 and 3, 4 and 2, 3 and 2 or vice versa. Trying each of these, we see that the only ones that will work are 4 and 3. The rest of the letters then fall in and the result is as follows

$$\begin{array}{r} 9364 \\ 893 \\ \hline 10257 \end{array}$$

Other solutions were also offered by the following: Margaret Joseph, Milwaukee, Wis.; James Means, Austin, Texas; Saul Hanges, Philadelphia, Pa.; Marie A. Moore, St. Louis, Mo.; C. W. Trigg, Los Angeles City College; Alan Wayne, Flushing, N. Y.; James A. Alstian, LaFayette, Ill., and E. Beberman, Shanks Village, N. Y.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

Bonnie Kleinmeyer; Melville Willard; Barbara Holstein; Paula Miller; Larry Littlejohn; Bill Tyler; Don Gabriel; Jack Potter; Ruben Guttierez; Wayne Stoner; Arthur Walters; John Albright; from Phineas Banning High in Wilmington, Calif.

PROBLEMS FOR SOLUTION

2215. *Proposed by Francis L. Miksa, Aurora, Ill.*

Given right triangle ABC, $C=90°$, drop CM perpendicular to AB, the hypotenuse. Let I_1, I_2, I_3, be the incenters of triangles ABC, ACM, BCM.

Show that the area of the triangle $I_1 I_2 I_3$ is given by

$$\Delta=\frac{a^2b^2(a+b-c)}{2c(a+b+c)}.$$

2216. *Proposed by C. W. Trigg, Los Angeles, Calif.*

In parallelogram $ABCD$, let $AB=m$ and $BC=n$. CB is extended to E so that $BE=m$, and CD is extended to F so that $DF=n$. Find the necessary relation between m and n in order that the intersection of DE and BF may fall on the diagonal AC.

2217. *Proposed by C. W. Trigg, Los Angeles, Calif.*

An integer which contains the nine non-zero digits is composed of three triads. The digits of the middle triad form an arithmetic progression. Geometric progressions may be formed by taking some order of the digits of each of the other triads. Show that there is only one such integer which is a multiple of 9801.

2218. *Proposed by W. R. Talbot, Jefferson City, Mo.*

If $a+b>c$ and $a^2+b^2=c^2$, show $a^3+b^3<c^3$.

2219. *Proposed by Julius Sumner Miller, New Orelans, La.*

Discover the properties of the number

$$\sqrt[3]{2+\frac{10}{9}\sqrt{3}}+\sqrt[3]{2-\frac{10}{9}\sqrt{3}}$$

2220. *Proposed by Julius Sumner Miller, New Orleans, La.*

Solve the equation: $x^4+4x^3-24x-24=0$.

BOOKS AND PAMPHLETS RECEIVED

ELEMENTS OF ALGEBRA, by Lyman C. Peck, M.S., *Department of Mathematics, The Ohio State University, Columbus, Ohio.* Cloth. Pages xiii+230. 14.5×23 cm. 1950. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.75.

STATISTICAL DECISION FUNCTIONS, by Abraham Wald, *Professor of Mathematical Statistics, Columbia University.* Cloth. Pages ix+179. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

TV INSTALLATION TECHNIQUES, by Samuel L. Marshall, *Television Instructor, George Westinghouse Vocational High School, New York City.* Cloth. 336 pages. 13.5×21 cm. 1950. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $3.60.

AN INTRODUCTION TO THE THEORY OF STATISTICS, Fourteenth Edition, Revised and Enlarged, by G. Udny Yule, M.A., F.R.S., *Formerly Reader in Statistics, University of Cambridge,* and M. G. Kendall, Sc. D., *Professor of Statistics, University of London.* Cloth. Pages xxiv+701. 15+22.5 cm. 1950. Hafner Publishing Company, Inc., 31 E. 10th Street, New York 3, N. Y. Price $7.00.

COLLEGE MATHEMATICS, by Charles E. Clark, *Associate Professor of Mathematics, Emory University.* Cloth. Pages v+331+46. 14.5×23 cm. 1950. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $3.85.

SOME THEORY OF SAMPLING, by William Edwards Deming, *Adviser in Sampling, Bureau of the Budget, Washington,* also *Adjunct Professor of Statistics, Graduate School of Business Administration, New York University.* Cloth. Pages xvii+602. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $9.00.

VATS, by Wilfrid S. Bronson. Cloth. 78 pages. 16×20.5 cm. 1950. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $2.00.

MATHEMATICS TO USE, by Mary A. Potter, *Supervisor of Mathematics, Racine, Wisconsin,* and Flora M. Dunn, Emmy Huebner Allen, John S. Goldthwaite. Cloth. Pages ix+502. 14.5×23 cm. 1950. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.40.

THE EVOLUTION OF SCIENTIFIC THOUGHT FROM NEWTON TO EINSTEIN. Second Edition, Revised and Enlarged, by A. D'Abro. Cloth, 481 pages. 13.5×20.5 cm. 1950. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.95.

ESSENTIALS OF BUSINESS ARITHMETIC, Third Edition, by Edward M. Kanzer, *Instructor in Business Education, Teachers College, Columbia University,* and William L. Schaaf, *Associate Professor of Education, Brooklyn College.* Cloth. Pages viii+476. 13.5×20.5 cm. 1950. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.36.

MID-CENTURY, THE SOCIAL IMPLICATIONS OF SCIENTIFIC PROGRESS, Edited and Annotated by John Ely Burchard, *Dean of Humanities, Massachusetts Insti-*

tute of Technology. Cloth. Pages xx+549. 15×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $7.50.

PHYSICAL CHEMISTRY, by Walter J. Moore, *Associate Professor of Chemistry, The Catholic University of America*. Cloth. Pages vii+592. 14.5×23 cm. 1950. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.00.

THE WORLD OF NUMBERS, BOOKS FIVE AND SIX, by Dale Carpenter, *Supervisor, Mathematics Education Section, Los Angeles City School Districts;* Edith M. Sauer, *Principal, Lincoln and Jefferson Elementary Schools, Springfield, Massachusetts;* and G. Lester Anderson, *Dean of Teacher Education for the New York City Colleges*. Cloth. 14×20.5 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.68 each.

LINEAR INTEGRAL EQUATIONS, by William Vernon Lovitt, Ph.D., *Professor of Mathematics, Colorado College*. Cloth. Pages ix+253. 13.5×20.5 cm. 1950. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.50.

CONTRIBUTIONS TO MATHEMATICAL STATISTICS, by R. A. Fisher, *Department of Genetics, University of Cambridge*. Cloth. Approximately 700 pages. 21×28 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N.Y. Price $7.50.

MAN THE MAKER, A HISTORY OF TECHNOLOGY AND ENGINEERING, by R. J. Forbes, *Professor of the History of Science and Technology at the Amsterdam Municipal University, Amsterdam, Netherlands*. Cloth. 355 pages. 13.5×21 cm. 1950. Henry Schuman, Inc., 20 East 70th Street, New York 21, N. Y. Price $4.00.

FREE AND INEXPENSIVE LEARNING MATERIALS. Paper. Pages vii+162. 13×21.5 cm. 1950. Division of Surveys and Field Services. George Peabody College for Teachers, Nashville, Tenn. Price 50 cents.

EDUCATION FOR A LONG AND USEFUL LIFE, by Homer Kempfer, *Specialist for General Adult and Post-High School Education*. Bulletin 1950, No. 6. Pages vi+32. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 20 cents.

BOOK REVIEWS

THE AUTOBIOGRAPHY OF ROBERT A. MILLIKAN. Cloth. Pages xiv+311. 15+23 cm. 1950. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $4.50.

This is the history of world progress during the lifetime of one of the greatest of physicists, educators, and authors, who has lived in the time of the world's most rapid advancement. It is the story of world changes of great magnitude as seen first by a little boy in a small town in Iowa, then by a student of physical education and of physics at Oberlin College, later by an instructor and a professor of physics at Chicago, and now by the eminent scientist of Caltech. Here we may read briefly of the measurement of *e* in the classic oil-drop experiment, of the introduction of science into World War I, of the famous vacuum barber shop experiment, of his decision to transfer from the great research laboratory of the University of Chicago to the small and almost unknown California Institute of Technology, where he became "associated with an institution which was likely to be active in following discoveries through to their applications" for "at Pasadena science and engineering were merged in sane proportions." Here at C.I.T. Millikan became the great leader of a number of eminent scientists who made this

little school one of our greatest institutions. Here was established a unique scheme of organization—an executive council consisting of eight men equal in authority and responsibility, subject only to the full board of trustees. This left the great research leaders free to carry on their investigations. The plan has worked admirably, for what institution has produced as much as C.I.T. in so short a time? We mention only a few sample projects: the million volt laboratory, the first million volt X-ray tube, the Guggenheim Airplane Laboratory with its work on the Douglas DC-3, the grinding and polishing of the great mirror, 17 feet in diameter, for Mt. Palomar, the production of rockets—more than 90% of all rockets used by the armed forces of the United States in World War II, the discovery of the positron and the mesotron; these are only a few of the great products of C.I.T.

In the last pages of the book Dr. Millikan shows his greatness in thought in the fields of morality, government, and religion. The last chapter is a famous sermon entitled, "The Two Supreme Elements in Human Progress." Here is the text: "Human well-being and all human progress rest at the bottom upon two pillars, the collapse of either one of which will bring down the whole structure. These two pillars are the cultivation and the dissemination throughout mankind of (1) the *spirit* of religion, (2) the *spirit* of science (or knowledge)."

The greater part of the book may be read by anyone with ease and enjoyment. Only a chapter or two contain material interesting especially to the scientist. All other chapters tell the story of great events in which he had an important part. Eight pages of photographs form a mid-section of the book. Students of science and history will be interested in the Appendixes A to E. The story is often varied to include interesting and amusing incidents. Your history of science shelf demands this book. Here are some thoughts worthy of your attention:

"The United States is far behind all other Anglo-Saxon countries and the whole of Europe in the provision it makes for the training of skilled workmen through vocational schools and *apprenticeships in industry.*"

"Why are we so far behind? Partly becaue those responsible for the work of the secondary schools have failed to give adequate attention to one of the most vital needs of American education, and partly because we who have the responsibility for the development of our higher educational system instead of setting up adequate hurdles for entrance to the higher schools have worshipped the god of numbers and through the accrediting system have made passage from secondary school to college almost a formality, rather than a careful sifting process designed as far as possible to prevent misfits in life, with their necessary accompaniments of unhappy lives and social unrest."

"Religion and science, then, in my analysis are the two great sister forces which have pulled, and are still pulling, manking onward and upward."

G. W. W.

TELEVISION FOR RADIOMEN, by Edward M. Noll, *Television Instructor in the Technical Institute of Temple University in Philadelphia.* Cloth. Pages xii+595. 15×23.5 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $7.00.

This book is intended especially for home study by radio service men but will serve equally well as a classroom text in high school, trade school, or elementary college classes. Nearly every topic of the text is illustrated by use of excellent drawings or photographs, well labeled, and large enough to be easily followed. Several folded pages give entire wiring diagrams and show clearly every part of the complete circuits. The book is mostly explanatory, mathematical equations being rarely used but these are well explained. Some knowledge of basic radio circuits is assumed. Each part of the equipment is thoroughly described after the explanation of the fundamental theories involved. Each chapter closes with a list of important questions for self check and a bibliography covering the topics discussed. This is especially important since much of the literature is still

in the field of the important journals. The author is a radio engineer with practical experience in the broadcasting industry and an excellent teacher of all types of radio engineering work.

G. W. W.

(I) MEANING AND UNDERSTANDING IN MATHEMATICAL INSTRUCTION; (II) THE PROBLEM OF PROBLEM-SOLVING IN MATHEMATICAL INSTRUCTION; (III) GEOMETRIC CONSTRUCTIONS, by Aaron Bakst, *School of Education, New York University*. Mimeographed, unbound. 21.5×28 cm. Pages: (I) i+45; (II) ii+53; (III) ii+59. 1950. New York University Bookstore, New York, N. Y. Price: (I) 90 cents; (II) 40 cents; (III) 75 cents.

These three monographs have been prepared for those who are now teaching or who are preparing to teach mathematics in secondary schools. Particularly in the case of the first two, there is considerable material along the lines which have been under discussion in recent years. It is quite possible that the reader will at points disagree with the viewpoint of that "crazy author"; but at least the reader may be forced to do some independent thinking. For example, one may or may not agree that "Algebra is not shorthand, and shorthand has no relation either to Algebra or to Mathematics," but the author's discussion of Language and Mathematics will cause some valuable thinking along certain lines. Similar statements could be made relative to the statement that functional relationship can only be explained in terms of *analogy* as well as in terms of *logical form*.

The reviewer was pleased to discover a mention of the fact that some of the conditions stated in a problem may be unnecessary (this might well be extended, for in actual problems there is usually an overabundance of conditions). The monograph on geometric constructions is unusually complete and contains in a relatively few pages material not readily found elsewhere. There is an exceptionally good classification of the methods available for solving geometric constructions.

These monographs are relatively inexpensive. One may object that at times the discussion seems unnecessarily lengthy; the lack of a permament binding and an index is unfortunate; nevertheless the material, particularly of the first two monographs, may help the teacher understand some of the modern discussion.

CECIL B. READ
University of Wichita

MODERN SCIENCE TEACHING, by Elwood D. Heiss, *Professor of Science, New Haven State Teachers College;* Ellsworth S. Obourn, *Head of the Science Department, John Burroughs School, Clayton, Missouri;* and Charles W. Hoffman, *Instructor in Physics and Physical Science, Temple University*. Cloth. 14×21 cm. 1950. The Macmillan Company, New York, N. Y. Price $4.50.

This edition is a revision of *Modern Methods and Materials for Teaching Science*. The text has two purposes: (1) to serve as a textbook for methods of teaching science; and (2) to serve as a source book for teachers of science, supervisors of science and science educators, at whatever level they may be working, who wish to keep abreast of present trends in the teaching of science. It accomplishes the first purpose well and the second as adequately as any text can at the time of printing.

The text has three sections: (1) the principles of science teaching, (2) science rooms and equipment, and (3) visual and other sensory aids used in teaching science.

The section on "Principles of Science Teaching" is modern in its approach and should, if properly supplemented, aid greatly in the orientation of old and new science teachers to the modern viewpoint regarding science instruction at all levels. The chapter on "Evaluation of Learning in Science" is modern and a comprehensive list of standardized tests is furnished.

The section on "Sensory Aids for Teaching Science" is most complete and should prove of value to all teachers of science.

The appendix has a list of sources of sensory aids and lists of equipment for teaching various sciences.

In short, the authors have made a thorough revision of their older text.

KENNETH E. ANDERSON
University of Kansas

MODERN CHEMISTRY, by Charles E. Dull, *Late Head of Science Department, West Side High School, Supervisor of Science for Junior and Senior High Schools, Newark, New Jersey;* William O. Brooks, *Chairman, Science Department, Technical High School, Springfield, Massachusetts;* and H. Clark Metcalfe, *Science Department, Brentwood High School, Pittsburgh, Pennsylvania.* Cloth. 16×23½ cm. 1950. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y. Price $3.16.

Modern Chemistry is a complete revision of a successful textbook of the same name originally written by the late Charles E. Dull. It is a better textbook than its predecessor in that it exemplifies the inductive method, is flexible, stresses practical applications, features chemistry of today, provides useful and ample activity material, and has a complete program of correlating materials.

Teachers considering a new adoption will do well to examine this thoroughly modern revision.

KENNETH E. ANDERSON

EXPERIMENTAL DESIGNS, by William G. Cochran, *Professor of Biostatistics, The John Hopkins University;* and Gertrude M. Cox, *Director, Institute of Statistics, University of North Carolina.* Cloth. 15×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.75.

The book is a thorough presentation of designs for experiments. The writers have outlined carefully the planning and carrying out of comparative experiments to provide specific answers to scientific questions under investigation.

The preliminary chapters stress the need for careful planning of experiments, methods for increasing the accuracy of experiments, and notes on the statistical analysis of results.

The balance of the book provides a detailed study of practical experimental designs. Each design is outlined so as to provide a plan of attack, instructions for its use in practice, and an account of the appropriate statistical analyses to be used.

Although the illustrations and problems are preponderately drawn from agriculture and biology, research workers in psychology and education will also find the book valuable in their type of work.

KENNETH E. ANDERSON

A LIST OF INTERESTING BOOKS FOR THE ELEMENTARY GRADES

A CHILD'S USE OF NUMBER, GRADES 1 AND 2, by Virgil S. Mallory, *Head of Department of Mathematics and Instructor in the Demonstration School, State Teachers College, Montclair, New Jersey;* Dennis H. Cooke, *President of High Point College, High Point, North Carolina;* and Esther F. Taylor, *Primary Teacher, Denver Public Schools.* Cloth. Pages vi+189. 13×20 cm. 1949. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago 16, Ill. Price $1.40.

An excellent little book for beginners, illustrated in color and emphasizing the use, meaning, and understanding of number and number processes. Designed to precede the Sanborn Arithmetic Series.

THE SIZE OF IT, A FIRST BOOK ABOUT SIZES, by Ethel S. Berkley, Cardboard. 25 pages. 16×19 cm. 1950. William R. Scott, Inc., 8 West 13th Street, New York, N. Y. Price $1.00.

Just a few pages to give children an idea of size. A lot of illustrations and a few sentences on each.

PLAY WITH TREES, by Millicent E. Selsam. Cloth. 64 pages. 15.5×20.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

A book for older children giving pictures and discussions of the common trees. Flowers, leaves, stems, buds, and seeds are shown in excellent drawings.

FROGS AND TOADS, by Herbert S. Zim. Cloth. 63 pages. 16.5×20.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

This is the sixth of Zim's books for children. Every youngster will be interested in it and will learn much about the value of frogs and toads.

RUBY THROAT: THE STORY OF A HUMMING BIRD, by Robert M. McClung, *Assistant in the Department of Mammals and Birds at the New York Zoological Park.* Cloth. 46 pages. 16.5×20.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

A very fascinating story of the little hummingbird, well illustrated in colors. An excellent gift book.

OWLS, by Herbert S. Zim. Cloth. 61 pages. 16.5×20.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

This book tells about all kinds of owls, their keen sight, remarkable hearing silent flight, and powerful muscles. It gives their remarkable use to man as hunters of rats and mice. No doubt there are new facts for you in this book for children.

SONG OF THE SEASONS, by Addison Webb. Cloth. 127 pages. 16×21.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.50.

Another excellent little book about some of the members of the animal kingdom, with many illustrations. Bears, rabbits, opossums, birds, bees, fish and many more. Illustrated in black and white.

INDIANS OF THE LONGHOUSE: THE STORY OF THE IROQUOIS, by Sonia Bleeker. Cloth. 160 pages. 12.5×18.5 cm. 1950. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

Not a story of raids and murder by either white settlers or the Indians but a story of one of the Indian tribes, how they lived, what crops they raised, their clothing, buildings, what they ate, their festivals, games, and how they were governed.

SOME LITTLE BOOKS FOR BIG PEOPLE

THE CAVE BOOK, by Charles E. Hendrix. Paper. 68 pages. 15.5×23 cm. 1950. The Earth Science Publishing Company, Revere, Mass. Price $1.00.

Mostly about the caves of Virginia but has a short chapter on the stone icicles and how they grow, another on the theories of cave formation, and still another on how to explore and map caves.

A CONCISE ENCYCLOPEDIA OF WORLD TIMBERS, by F. H. Titmuss. Cloth. Pages v+156. 14×21.5 cm. 1949. Philosophical Library, Inc., 15 East 40th Street, New York, N. Y. Price $4.75.

A book which contains the most essential characteristics of about 200 different kinds of timber. Designed as reference book for the wood-worker.

Radio and Television Mathematics: A Handbook of Problems and Solutions, by Bernard Fischer, Ph.D., Vice President in Charge of Training, American Television Laboratories of California. Cloth. Pages xviii+484. 13×20 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $6.00.

A practical handbook for workers in the various branches of electronics. Nearly 400 solutions, many with diagrams. Contains discussion of the slide rule, the J-operator, and polar vectors. Another section gives the many formulas used and tables of logarithms, sines, cosines, and tangents.

Human Growth. The Story of How Life Begins and Goes On. Based on the Educational Film of the Same Title, by Lester F. Beck, Ph.D. *Associate Professor of Psychology, University of Oregon.* Cloth. 124 pages. 13×20 cm. 1949. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $2.00.

A book of sex education for teen age children. Its chief purpose is to create a healthy mental attitude by telling the honest story of human development and growth.

Guidance Handbook for Teachers, by Frank G. Davis, Ph.D., *Professor of Education, Bucknell University, Lewisburg, Pennsylvania,* and Pearle S. Norris, M.A., *Counselor, Public Schools, Philadelphia, Pennsylvania.* Cloth. Pages x+344. 15×23 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $3.50.

A book planned especially for the individual teacher rather than for a full-time guidance specialist. It gives definite directions for getting the facts, evaluating them, and then applying them in order to care for the needs of the child.

Author's Guide for Preparing Manuscript and Handling Proof, by John Wiley and Sons. Cloth. Pages xi+80. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $2.00.

This is a book which should be in the hands of everyone who is preparing manuscript for publication. It may help you get your article published when another of equal value is turned back.

RECORD AMOUNT OF FERTILIZERS PRODUCED, ENOUGH FOR ENTIRE WORLD

Without fertilizer, the world would be a lot hungrier than it is. But this summer, the Food and Agriculture Organization of the United Nations reports, a vital postwar corner was turned. A record amount of fertilizer is being produced—enough, for the first time since World War II, to satisfy world demand.

For the fiscal year ending June 30, nearly 13,000,000 metric tons of fertilizer was produced, an all-time record. Russia was the only major country not included in the FAO statistics.

In the coming year—barring effects of the Korean conflict—FAO commodity experts predict fertilizer output and consumption will go up another seven percent. "Because countries can now plan crop production programs on a broader base of available fertilizer supply, their agronomic needs can be better satisfied," the report states. In terms a hungry world can better understand, the outlook for more food is good.

SUGGESTED REVISIONS OF THE BY-LAWS

Central Association of Science and Mathematics Teachers

I. Members

Section I. Qualifications: Any teacher or other person, firm, or corporation, interested in any aspect of the teaching of science or mathematics shall be eligible for membership in this association.

Section IV. Dues: The annual dues of each member of the association shall be $3.50, payable in advance. The annual dues shall entitle the member to receipt of the Journal.

Section V. Voting: Each member of the association shall be entitled to one vote.

III. Officers

Section I. Officers: The officers of this association shall be a President, a Vice-President, a Secretary, a Treasurer and Business Manager, an Editor of the Journal, and an Historian. One or more Assistant Secretaries and Assistant Treasurers may be appointed by the President.

Section II. Qualifications: The President shall be nominated from the Board of Directors. The Vice-President shall have served at some time on the Board of Directors for at least one year.

Section III. Election, Tenure of Office, Compensation: The President and Vice-President shall be elected by the members of the association at the annual meeting and shall serve for a term of one year or until their successors are elected. The Treasurer and Business Manager, Editor of the Journal, Historian, and Secretary shall be appointed by the Board of Directors at a meeting to be held following the annual meeting of the association, and shall serve for a term of three years. Their terms may be renewable. The compensation of the officers, if any, shall be fixed by the Board of Directors.

Section IV. Powers and Duties of Officers: (a) President: The President shall preside at all general meetings of the association and shall perform the usual duties of his office. He shall be chairman of the Board of Directors and chairman of the Executive Committee, and shall perform the usual duties of those offices.

(b) Vice-President: He shall act for the President in the latter's absence. He shall also serve as a member of the Executive Committee.

(c) Secretary: The Secretary shall keep all records, minutes of all meetings and shall prepare and submit a complete report of the annual meeting to the Editor of the Journal by December 31 following the meeting.

(d) Treasurer and Business Manager: The Treasurer and Business Manager shall collect all dues and hold all moneys and keep a record of all receipts and disbursements. He shall give a report at the annual meeting of the association. He shall pay out funds on the order of the Board of Directors and the Executive Committee. He shall also act as Business Manager of the Journal.

(e) Editor of the Journal: The Editor of the Journal shall be responsible for the Journal, in all phases except business management.

(f) Historian: The Historian shall be charged with the responsibility of collecting and preserving the historical documents of the association.

IV. Board of Directors

Section II. Number. There shall be fifteen (15) members of the Board of Directors. The President, the Vice-President, the President of the preceding year shall be members of the Board of Directors. The remaining members of the Board of Directors shall be divided into three groups of four (4) directors each. Four directors shall be elected annually to succeed those of the group whose terms are about to expire.

SECTION IV. ELECTION, TENURE OF OFFICE AND COMPENSATION: Directors shall be elected by a majority vote of the members present at any annual meeting. They shall assume the duties of their office immediately preceding the adjournment of the annual meeting and shall serve for a period of three years or until their successors are elected. They shall serve without compensation, except that they may be allowed a reasonable compensation for traveling, and necessary expenses incurred by them in the discharge of their official duties.

Vacancies in the Board of Directors or list of officers shall be filled by the Board of Directors at any meeting thereof. A director so chosen shall serve until the next annual business meeting when a successor shall be elected to fill the unexpired term.

Whenever directors are elected, whether at the expiration of a term or to fill vacancies, a certificate under the seal of the association giving the names of those elected and the term of their office shall be recorded by the Treasurer and Business Manager in the office of the recorder of deeds where the certificate of organization is recorded.

SECTION VIII. POWERS AND DUTIES: The Board of Directors shall (1) have general supervision of the activities of the association; (2) authorize the expenditure of funds; (3) fix the salary and bonds of the officers; (4) fill vacancies.

V. EXECUTIVE COMMITTEE AND OTHER COMMITTEES

SECTION I. EXECUTIVE COMMITTEE: (a) MEMBERS: Members of the Executive Committee shall consist of the President, Vice-President, and immediate past president and shall serve for one year or until their successors have been elected.

SECTION IV. PROFESSIONAL SECTIONS AND GROUPS: The association may be organized into sections and groups. The organization and activities of the sections or groups shall be determined from time to time by the Board of Directors. Unless otherwise provided by the Board of Directors each section or group shall elect its own Chairman, vice Chairman and Secretary.

SECTION VII. THE POLICY AND RESOLUTIONS COMMITTEE: The Policy and Resolutions Committee shall consist of six (6) members. Each member shall serve three years. Two members shall be chosen annually by the President to replace the two whose terms are about to expire. One of those chosen annually must be from the Board of Directors. The President will annually designate the chairman of this committee. The chairman so selected shall have been a member of the committee for at least one year.

NEW SCHOOL BUILDINGS NEEDED

School building needs are much greater today than they were before World War II, the Commissioner of Education asserted. Today's acute shortage of school facilities is due primarily to deferral of construction during the period from 1941 to 1945, to a shifting population during and since the war, to reconversion activities, and to the record numbers of children born during the same period who now are of school age. Thousands of children during 1950–51 and for several years ahead will attend overcrowded and makeshift classrooms. Large numbers of pupils will be required to attend school on a half-session plan. Thousands of boys and girls will be taught in buildings that may be insanitary and unsafe. The Office of Education pointed out that fire takes a daily toll of 10 children in the United States.

School problems will become more critical this year in many areas of Federal activity as defense projects are reactivated, as reclamation and flood control projects are expanded, and the result of military housing programs, according to the Office of Education. The Congress has been planning Federal financial assistance to such areas.